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ASTM BULLETIN

Published by
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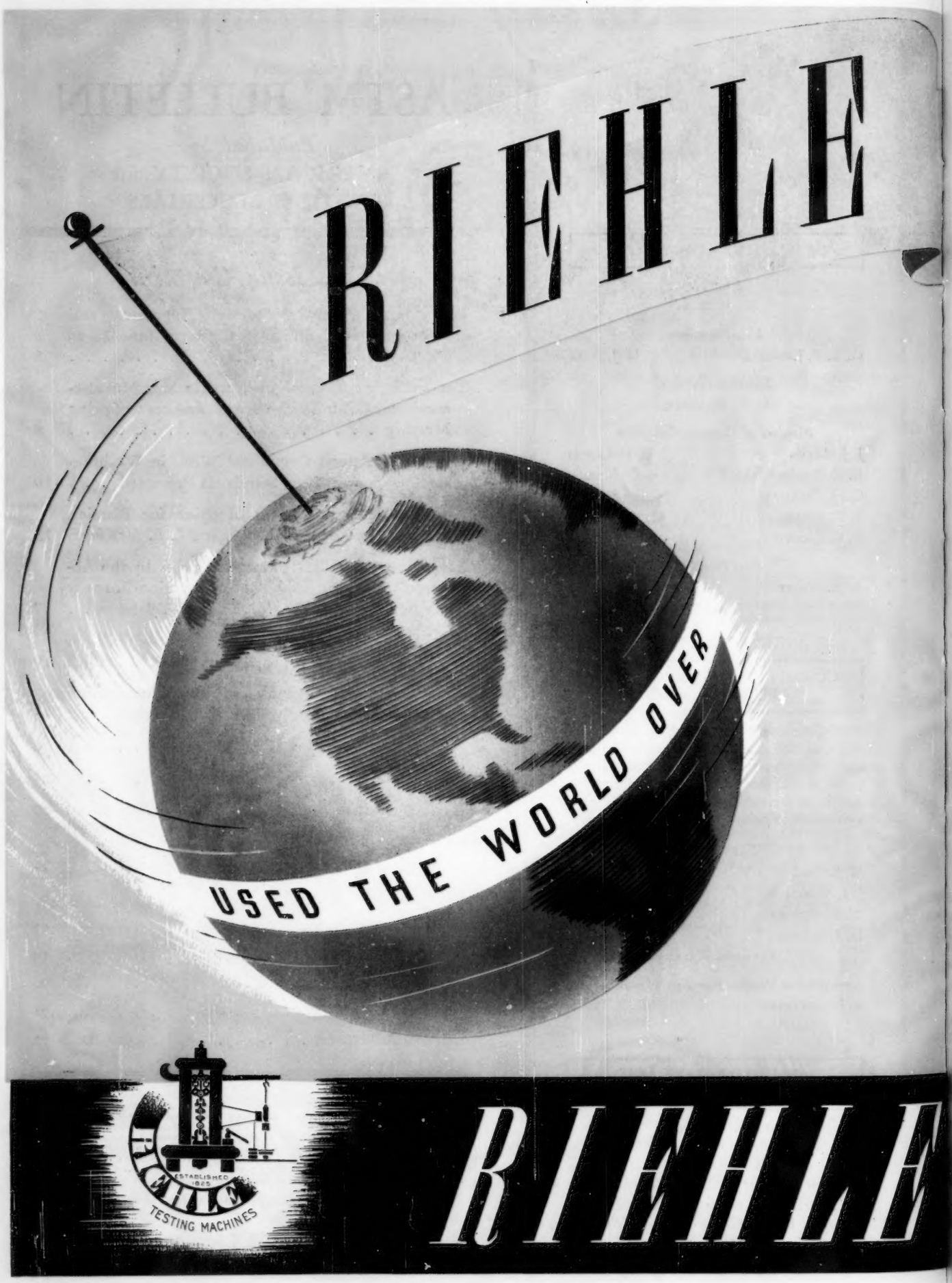
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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering and Standardization of Specifications and Methods of Testing"

TELEPHONE—PENnypacker 3545 R. E. Hess, Editor CABLE ADDRESS—TESTING

R. J. Painter, Associate Editor

Number 109 March, 1941

Forty-fourth Annual Meeting in Chicago, June 23 to 27, 1941

A Large Number of Technical Papers; Apparatus and Photographic Exhibit; Other Events to Feature Meeting

In addition to a very interesting technical program which is in course of development by the Society's Committee on Papers and Publications, including certain features being handled by the Chicago Committee on Arrangements, headed by E. R. Young, Climax Molybdenum Co., the Sixth Exhibit of Testing Apparatus and Related Equipment will be in progress, the 1941 Photographic Exhibit and Competition will be held, a special smoker is planned, and Golf Tournament and other events are being developed for the 1941 annual meeting which will be held in Chicago at The Palmer House, June 23 to 27. Two very interesting annual meetings have been held in Chicago, one in 1931 and the other in 1933 during what was termed "Engineering Week" of the Century of Progress. In March, 1937, the Spring Meeting and Committee Week were held at The Palmer House.

Chicago Committee on Arrangements

Arrangements for the meeting and the number of continuous activities which are part of it are being directed by the Chicago District Committee which has been amplified by the addition of a number of other members and committee members into a larger group called the Chicago Committee on Arrangements. This includes representatives of many of the major industries in the area. A complete list of the Committee on Chicago Arrangements will be published later.

Meanwhile, the district committee has left with an Executive Committee, consisting of the three officers of the committee and the chairman of the program committee, responsibility for organizing various subcommittees that have been set up. The Executive Committee of the Chicago group consists of the following:

E. R. Young, *Chairman*, Metallurgical Engineer, Climax Molybdenum Co.

J. de N. Macomb, *Vice-Chairman*, Assistant to Vice-President, Inland Steel Co.

C. E. Ambelang, *Secretary*, Engineer, Public Service Co. of Northern Illinois.

J. F. Calef, *Chairman, Program Committee*, Chief Chemist, Automatic Electric Co.

There have been a number of meetings of this group and the district committee, and several of the subcommittees have also held organization meetings and covered various problems which must be handled. This includes the Committee on the Photographic Exhibit and Competition and the Program Committee.

The subcommittees which are being appointed and their chairmen are as follows:

Program Committee—J. F. Calef, Chief Chemist, Automatic Electric Co.

Finance Committee—J. E. Ott, Mechanical Engineer, Acme Steel Co.

Apparatus Exhibit Committee—Arthur Howe Carpenter, Associate Professor of Metallurgy, Armour Institute of Technology

Photographic Exhibit Committee—A. W. Laird, Metallurgical Engineer, Western Electric Co., Inc.

Publicity and Promotional Committee—J. J. Kanter, Research Metallurgist, Crane Co.

Entertainment Committee—H. P. Bigler, Director, Rail Steel Bar Assn.

Golf Committee—H. B. Emerson, Manager, Service Dept., Lehigh Portland Cement Co.

Trip Committee—W. A. Straw, Superintendent of Development Engineering, Western Electric Co., Inc.

Membership Committee—C. H. Jackman, Manager, Structural and Plate Bureau, Metallurgical Division, Carnegie-Illinois Steel Corp.

A Ladies Entertainment Committee is also being organized. A number of special features are being planned by the Chicago group—one of these will be a smoker and cocktail party at which members of the Society will be the guests of the Chicago Committee. Further announcements will be made concerning entertainment features, including the Golf Tournament.

Technical Program

The Program Committee is cooperating with the Society's Committee on Papers and Publications in developing portions of the program. The committee is obtaining the feature speaker at the opening session and also plans a special session with papers and addresses of interest broadly to A.S.T.M. members but on specific topics peculiar to the Chicago area.

Since advance details of the technical program will be given rather completely in the May issue of the ASTM Bulletin with a synopsis of each item, only a general

outline seems desirable at this time. One of the prominent features will be a Symposium on Problems and Practice in Determining Steam Purity by Conductivity Methods, with papers on the following subjects:

Introduction—R. E. Hall, Hall Laboratories, Inc.

The Sampling of Steam and Boiler Water—A. H. Moody and A. R. Belyea, Consolidated Edison Co. of New York, Inc.

Experimental Methods of Determining the Conductivity Correction Factors for Dissolved Gases in Steam Condensate—S. F. Whirl, Duquesne Light Co.

Calculation of Corrections to Conductivity Measurements for Dissolved Gases—D. S. McKinney, Carnegie Institute of Technology

Degasification of Steam Samples for Conductivity Tests—P. B. Place, Combustion Engineering Co.

Conductivity Cells and Electrical Measuring Instruments for Determination of Specific Conductance of Electrolytes—R. T. Hanlon, Consolidated Edison Co. of New York, Inc.

This symposium is being held under the auspices of Committee D-19 on Water for Industrial Uses, with Max Hecht, chairman, and R. E. Hall, secretary. Mr. Hall is serving as chairman of the Symposium Committee in charge.

At its February meeting, Committee E-6 on Papers and Publications reviewed in detail each of the large number of offers of papers that have been submitted and after considering the program broadly as a whole, a number of offers were accepted. Of these several pertain to the field of ferrous and non-ferrous metals, specifically relating to problems of corrosion, fatigue, information and data on properties and tests of ferrous metals and alloys, and related subjects. The largest number of items accepted was in the nonmetallic field and involve such topics as glass, gaseous fuels, asphalt, various methods of testing certain products, an important contribution on the testing of volumetric glassware, fineness measurements and the like. With offers of several papers covering topics in the field of plastics such as resistance of these materials to chemical reagents, factors influencing cold flow properties, and the influence of molding conditions on shearing strength of plastic materials, a separate session devoted entirely to this subject is in prospect. In this field, of course, A.S.T.M. Committee D-20 on Plastics is extremely active and at recent annual meetings of the Society there have been a number of outstanding technical contributions covering important problems in this field.

Of particular interest to the large groups concerned with concrete and constituents thereof is the decision of Committee C-9 to sponsor this year a revised Symposium on the Significance of Tests of Concrete which was issued in published form in 1935. Each section of the symposium is being studied and five of these as amplified and extensively revised are to be presented at the meeting for discussion. Outstanding authorities in the field will prepare portions of these reports in cooperation with the other members of the committee.

Hotel Reservations

While there will be sent early in May to each member a reservation blank giving hotel rates at The Palmer House with other details, members who wish to do so can write for reservations now. As a matter of fact, we know of some members who have already taken this step. However, no difficulty is anticipated in obtaining desired room facilities at The Palmer House which has always made it a point to cooperate fully in this respect.

To an increasing extent members of the Society have been bringing their families to the annual meetings and there are a great many interesting places to see in Chicago and its environs and many things for the families to do.

Apparatus Exhibit to Focus Attention on Testing and Research

Throughout the five days of the annual meeting, June 23 to 27, at The Palmer House, Chicago, there will be in progress the A.S.T.M. Sixth Exhibit of Testing Apparatus and Related Equipment. As in the previous odd-numbered years this will focus attention on the wide range of testing instruments, laboratory supplies, recording apparatus and scientific and kindred equipment which is available for investigations in the field of materials. Many of the leading producers and distributors of instruments will participate in the Exhibit and there will be a number of special displays sponsored by various research institutions and industrial companies in the Chicago area which have developed special apparatus for research work.

Not only does the Exhibit afford an excellent opportunity for the hundreds of members and visitors who attend to gain an idea of the latest developments and improvements in more standardized equipment, but the Exhibit has come to be recognized as an important adjunct to the meeting every two years by focusing attention on the importance of instrumentation in connection with the Society's research and standardization work in the field of materials.

The Apparatus Exhibit Committee, headed by Professor Carpenter, will assist in the development of research and special displays.

Another advantage of the Exhibit is the opportunity afforded standing committees to sponsor displays of their work. All of the committee displays in previous years have been most interesting and have been very educational to many members who did not realize the scope and activities of the various groups.

An advance list of the companies which will participate in the commercial section of the Exhibit follows. A number of other organizations will undoubtedly take part and members can look forward to very representative displays with booths manned by competent representatives who can discuss intelligently with the members various problems.

Atlas Electric Devices Co.
Baldwin-Southwark Corp.
Christian Becker, Inc.
Brabender Corp.
Adoph I. Buehler
Central Scientific Co.
Coleman Electric Co
Eastman Kodak Co.
Gaertner Scientific Corp.
Emil Greiner Co.
Humboldt Manufacturing Co.
Illinois Testing Labs.
Instrument Specialties Co., Inc.
Kimble Glass Co.
Lancaster Iron Works, Inc.
Leeds & Northrup Co.
National Carbon Co.
Parr Instrument Co.
Precision Scientific Co.
Radium Chemical Co.
Riehle Testing Machine Division, American Machine and Metals, Inc.
E. H. Sargent and Co.
Schaar and Co.
C. J. Tagliabue Manufacturing Co.
Wilson Mechanical Instrument Co.

Development of 1941 Photographic Exhibit

THE COMMITTEE in charge of the 1941 Photographic Exhibit to be sponsored by the Society during the Forty-fourth Annual Meeting at The Palmer House, Chicago, June 23 to 27, held an extended meeting recently in Chicago, discussed fully a number of points in connection with the competition and display, and considered ways and means of developing an exhibit which should be of widespread interest to all A.S.T.M. members.

The committee which will have charge of the exhibition is one of several subgroups of the Chicago Committee on Arrangements to which reference is made in another part of this BULLETIN. A. W. Laird, Western Electric Co., heads the committee, the complete personnel of which is as follows:

A. W. Laird, *chairman*, Western Electric Co.; T. C. Bennett, Leeds & Northrup Co.; Cromwell Bowen, Robert W. Hunt Co.; W. F. Crawford, The Edward Valve and Manufacturing Co., Inc.; E. R. Seabloom, Crane Co.; M. A. Grossman, Carnegie-Illinois Steel Corp.; Alfred Herz, Public Service Co. of Northern Illinois; Thor Nielsen, Carnegie-Illinois Steel Corp.; and J. E. Ott, Acme Steel Co.

Mr. Nielsen is representing Doctor Grossman, Vice-Chairman of Committee E-4 on Metallography, which is in charge of the section of the exhibition being devoted to photomicrography, following the plan in effect at the 1939 meeting. Full details of the exhibition are incorporated in an entry form-descriptive folder now in preparation, a copy of which will be sent to each A.S.T.M. member and committee member in the next few weeks.

A FEW FACTS ABOUT THE EXHIBITION

Theme: Materials, Testing, and Research:

This year, photographs featuring the human element or personnel factors are especially desired, as well as photographs of instruments, apparatus, and related items. Photographs showing unique or unusual applications of materials are also welcomed.

Both professional and nonprofessional photographs are solicited. Nonprofessional is being construed as applying to any A.S.T.M. member or employee of a member company whose principal occupation is not photography; professional prints will not be judged in the competition unless submitted by members, member companies, or associates of members.

Following the plan of previous years, judging will be based on how well the photograph tells the story, timely interest, and importance of subject matter. Certificates of merit will be awarded for first, second, and third place, and honorable mention in both the nonprofessional and professional classes. Photographs must be mounted on 16 by 20-in. white or buff mounts, in a vertical position, and it is specified as in the last exhibitions that no written or printed material should appear on the front of the mount since the committee will affix in uniform style the title as given by the photographer, the photographer's name and company.

Color Transparencies:

This year, the committee, conscious of the intense interest in color work, solicits color transparencies if properly identified and mounted as standard 2 by 2-in. slides. It is not planned that the transparencies will be judged with the other entries.

Section on Photomicrography:

One of the very interesting sections of the 1939 Photographic Exhibit was devoted to photomicrography. Even though Committee E-4 on Metallography has felt it desirable to sponsor this section only every two years, a number of interesting photomicrographs were received in 1940 and the committee in charge was glad to hang them because of the interest in this work. The general rules applicable to the photographic exhibit will be in force, but the methods of judging will be determined by Committee E-4 through Messrs. Grossman and Nielsen. All metallographists and those concerned with the general subject of photomicrography—whether it pertains to metals, textiles, paints or whatever—are urged to keep the exhibit in mind and to submit entries. The entry blank will cover both the general Photographic Exhibit and the section on photomicrography.

Further details will be sent to the members and committee members later.

"Demonstrating Extinguishing Effect of Air-Foam on a Gasoline Fire"

Awarded honorable mention, professional class, in the Third A.S.T.M. Photographic Exhibit; submitted by C. R. Nelson, Associated Factory Mutual Fire Insurance Cos.

Technical Symposiums on Particle Size Measurement and Color Draw Large Numbers to Spring Meeting

INTENSE INTEREST in the subject of particle size measurement and in color and its use in evaluating the properties of materials was demonstrated by the large attendance at the three technical sessions of the A.S.T.M. Spring Meeting in Washington at which were presented the 13 technical papers and discussion comprising the symposiums.

The sessions on particle size were held on the afternoon and evening of March 4, and the six papers in the color symposium which was sponsored jointly by the A.S.T.M. and the Inter-Society Color Council were given on the afternoon of March 5. Attendance at each afternoon session was approximately 300, but at the evening session on particle size it was well over this figure.

General arrangements for the 1941 Spring Meeting and A.S.T.M. Committee Week, March 3 to 7, were handled by a Washington Committee headed by Vice-President G. E. F. Lundell, the complete personnel of the committee being as follows:

G. E. F. LUNDELL, *Chairman*, Chief, Chemistry Division, National Bureau of Standards
H. S. RAWDON, *Secretary*, Chief, Division of Metallurgy, National Bureau of Standards
T. I. COE, Technical Secretary, Department of Technical Services, American Institute of Architects
W. E. EMLEY, Chief, Division of Fibrous and Organic Materials, National Bureau of Standards
A. C. FIELDNER, Chief, Technologic Branch, U. S. Bureau of Mines
H. A. GARDNER, Chemical Engineer, The Institute of Paint and Varnish Research
F. H. JACKSON, Senior Engineer of Tests, Public Roads Administration, Federal Works Agency
G. F. JENKS, Colonel, Ordnance Dept., U. S. Army
FRANCIS SCOFIELD, Chemist, National Paint, Varnish and Lacquer Assn., Inc.
STANTON WALKER, Director of Engineering, National Sand and Gravel Assn.

The committee did an excellent job in taking care of meeting details and in stimulating interest in the technical sessions as well as in the committee meetings.

During the symposiums it was announced that the papers and discussion would be issued in special publications during the early summer, thus making available in convenient form the valuable information and data which were given.

SYMPOSIUM ON NEW METHODS FOR PARTICLE SIZE DETERMINATIONS IN THE SUBSIEVE RANGE

The symposium on particle size measurement was developed under the auspices of one of the Society's committees with C. E. Barnett, New Jersey Zinc Co., acting as Chairman of the Symposium Committee. Dr. L. T. Work, Director of Research and Development, Metal and Thermit Corp., cooperated closely with Mr. Barnett and served as chairman of the evening session. The seven papers comprising the symposium were as follows:

The Shape and Surface of Fine Powders by the Permeability Method—P. C. Carman, University of Capetown (Presented by R. L. Blaine, National Bureau of Standards)

Surface Area of Portland Cement—P. S. Roller, U. S. Bureau of Mines, and P. V. Roundy, Jr., American Instrument Co.

Methods for Determining Particle Size Distribution—Lincoln T. Work, Metal and Thermit Corp., and Herbert E. Schweyer, Columbia University

RCA Electron Microscope—James Hillier, RCA Manufacturing Co.

The Adsorption of Pigments—W. W. Ewing, Lehigh University

A New Method for Measuring the Surface Areas of Finely Divided Materials and Its Use in Determining the Size of Particles—P. H. Emmett, Johns Hopkins University

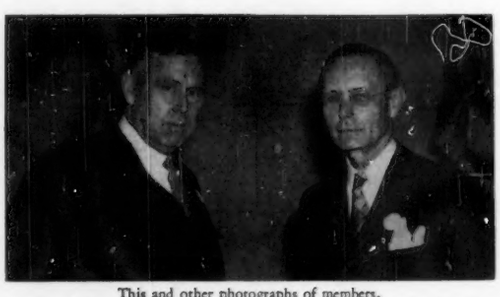
The Determination of Subsieve Particle Size Distributions by Sedimentation Methods—S. W. Martin, National Lead Co.

While the paper by Messrs. Work and Schweyer, providing a general survey of this entire field and descriptions of the various methods used, might have given the impression to the uninformed listener that this field was in a somewhat undeveloped state, it is evident from the discussion of the other papers that great progress had been made in particle size determination. Further evidence of this was given by the definite correlation shown in the work of Mr. Emmett and that of the new electron microscope.

In his paper, which was presented by R. L. Blaine of the National Bureau of Standards, Professor Carman concluded that his permeability method gives somewhat high values for specific surface of very fine particles. Other methods may vary on the opposite side. This method of fineness can be compared to a bed in a sand filter or a water supply system through which the water filters at a rate which depends upon the pores. From this rate, knowing certain factors, the size of the pores and in turn the surface of the filtering material can be computed. Preferably, some liquid is used in this method which does not react with the materials being measured. It was indicated that the method was applicable to fine material in sizes of about 40 microns down to one micron.

In a discussion of his work on measuring surface area of portland cement, Mr. Roller gave data showing comparisons between the Wagner turbidimeter, a method using an air analyzer, and an air permeability method. In every case the Wagner turbidimeter method gave lower results than the other two, that is, low values for surface areas.

Vice-President G. E. F. Lundell and President W. M. Barr.



This and other photographs of members, courtesy of R. F. Adams, Managing Editor, *Paint, Oil and Chemical Review.*

There was widespread interest in Mr. Hillier's description of results with the electron microscope. He confined his discussion primarily to the application of the instrument in investigating the size of fine material, particularly carbon black of a type used in rubber compounds. Certain biological applications of the instrument were discussed, including its applicability in studying virus such as the tobacco mosaic virus. While the instrument has not seemed to be suited for extensive application in metallographic studies because of the thin film which it is necessary to use in order to project electrons through the specimens, studies are being made of the possibilities in this field. For example, corrosion films might be a subject of study.

There was a great deal of discussion on the papers presented by Professors Emmett and Ewing involving adsorption properties, that of Emmett's using gas and Ewing's using wetting agents. The gas method is considered particularly valuable where the material has a sponge-like nature with a large internal surface. Calculations are based on pressure variations. Professor Emmett's method of surface area measurements depends upon making adsorption isotherms of some gas such as nitrogen near its boiling point and then selecting on the isotherm the volume of gas corresponding to a monolayer. A simple multiplication of the number of molecules in such a monolayer by the average cross-sectional area of the molecules yields a value for the surface area. In commenting on this method Mr. Hillier showed a good correlation between the adsorption method and the results he obtained with the electron microscope. Others present gave data on the good reproducibility of the method as between different laboratories.

The method described by S. W. Martin of the National Lead Co. is believed particularly applicable in measuring what might be called "effective particle size," that is, the size of the material as it exists in practical applications. A rouge which may be fairly coarse when used in polishing glass gradually breaks down and becomes finer. This method distinguishes between particle size differences in pigments used in rubber and in paint, probably caused by more work being done on the particles and greater dispersion in the rubber than in the paint.

Symposium on Color—Its Specification and Use in Evaluating the Appearance of Materials

The six papers comprising the symposium on color, which was sponsored jointly by the A.S.T.M. and the Inter-Society Color Council and developed by a committee headed by M. Rea Paul, Director, Technical Paint and Color Service, National Lead Co., who is past-chairman of the Inter-Society Color Council, and also secretary of A.S.T.M. Committee D-1 on Paint, Varnish, Lacquer, and Related Products, were presented on Wednesday afternoon. About 325 technologists from a wide variety of materials fields were in attendance, many participating in the discussion. A list of the papers and those responsible for them follows:

Introduction to Color—Deane B. Judd, National Bureau of Standards

Color of Transparent Materials—Francis Scofield, National Paint, Varnish and Lacquer Assn., Inc.

Hiding Power and Opacity—R. H. Sawyer, Krebs Pigment and Color Corp.

Color Standards for Opaque Materials—I. H. Godlove, E. I. du Pont de Nemours and Co.

The Spectrophotometer in the Determination of the Color of Materials—A. E. Parker, Electrical Testing Laboratories

Photoelectric Colorimetry—Richard S. Hunter, National Bureau of Standards

Technical Symposiums to Be Published

The papers comprising the Symposiums on New Methods for Particle Size Determination, and Color—Its Use in Evaluating the Appearance of Materials, will be published in special volumes. The volume on color will be ready probably early in May and the one on particle size measurement in the early summer.

Attention is called to the fact that those wishing to submit written discussion of any papers should send this to A.S.T.M. Headquarters before April 15.

If one had to summarize in a very short statement the significance of this important technical contribution, it would be that it will provide, when published, in convenient form an understandable, trenchantly expressed summary of our latest knowledge on the subject covered. And if this were the only result it would have amply justified the efforts of those who contributed to its success, because there is rapidly growing realization of the importance of color in many fields.

An excellent abstract of his fundamental paper on "Introduction to Color" by Deane B. Judd was published in the January ASTM Bulletin. In this he describes color, differentiates between hue, lightness, etc., covers the systems of describing colors and also methods of specifying color, in particular the tristimulus specifications. In the work of the Society involving materials, this is of the utmost significance and the Society's Committee D-1 is developing some standards making use of the ICI standard observer and coordinate system for colorimetry. He mentioned material color standards which are used in a number of A.S.T.M. tests and specifications.

Messrs. Scofield and Godlove in their well-prepared papers covered various problems as indicated in the titles. Questions of instrumentation and practical problems which must be met were covered and Mr. Godlove delineated a large number of standards which are in daily use, giving the significance of some of them and their limitations. Mr. Parker discussed the applications of the spectrophotometer, pointing to the increasing use of recording instruments and Mr. Hunter described photoelectric tristimulus colorimetry which is used in evaluating the appearance of materials.

W. H. Gardner, Brooklyn Polytechnic Institute, and Clinton Grove, United Color and Pigment Co.

Over 1000 Attend Committee Week

New Standards Proposed; Important Research Developments

THE 1941 A.S.T.M. COMMITTEE WEEK held in Washington, D. C., March 3 to 7, inclusive, at The Mayflower, was marked by more meetings of the Society's technical committees than have been held in any previous year and by the registration of over 1000 materials engineers and testing experts.

This Committee Week, as it has come to be termed, provides an opportunity for scheduling meetings of as many committees as wish to take part, in a concentrated period, thus conserving the time of members at meetings, traveling expenses, and the like. While the location influences the number of committees taking part, the unusual extent of these 1941 meetings and the results of the sessions are definite indications of the intense activity in materials standardization and research.

The registration figure 1020 does not include those attending meetings of two Society groups covering electrical insulating materials and plastics which were also held in Washington during the same week at another hotel.

Practically every one of the more than 200 meetings, including subcommittee and main committee meetings, was well attended. Resulting from the discussions will be many new purchase specifications, testing procedures, needed research data on materials and other information. Most of the material will be included in the annual reports of the committees to be presented at the Society's annual meeting in Chicago—June 23 to 27.

There was notable acceleration of the Society's work in developing quality specifications for materials undoubtedly brought about in large part by national defense exigencies, but also responsible is the more streamlined action which recently has become in effect in the Society's standardization procedure.

A list of the committees which met in Washington follows. In most cases a number of subcommittee meetings and sections were also held in connection with the main committee meetings.

The outlines given below of various committee activities will give some idea of the progress made and of the programs which the committees have under way. *Most of the actions taken at the meetings will, of course, be submitted to letter ballot prior to formal recommendation to the Society*, this being particularly true in the case of actions in the standardization field. It will be noted that many new standards are being considered for recommendation to the Society for publication as tentative and that a number of existing tentative specifications and tests will be offered for formal adoption as A.S.T.M. standards.

A-1 on Steel
A-3 on Cast Iron
A-5 on Corrosion of Iron and Steel
A-6 on Magnetic Properties
A-7 on Malleable Iron Castings
A-10 on Iron-Chromium-Nickel

B-2 on Non-Ferrous Metals and Alloys
B-3 on Corrosion of Non-Ferrous Metals
B-5 on Copper and Copper Alloys
B-6 on Die-Cast Metals and Alloys
B-7 on Light Metals and Alloys
B-8 on Electrodeposited Metallic Coatings

C-5 on Fire Tests of Materials
C-7 on Lime
C-8 on Refractories
C-9 on Concrete and Concrete Aggregates
C-11 on Gypsum
C-15 on Manufactured Masonry Units
C-16 on Thermal Insulating Materials
C-18 on Natural Building Stones

D-1 on Paint, Varnish, Lacquer
D-3 on Gaseous Fuels
D-4 on Road and Paving Materials
D-5 on Coal and Coke
D-8 on Bituminous Waterproofing and Roofing Materials
D-11 on Rubber Products
D-13 on Textile Materials
D-18 on Soils for Engineering Purposes

E-1 on Methods of Testing (Sections only)
E-4 on Metallography
E-9 on Research

Joint Committee on Definitions of Terms Relating to Heat Treatment

Research Committee on Fatigue of Metals

In addition Committees D-9 on Electrical Insulating Materials, D-20 on Plastics, and Sectional Committee C59 on Electrical Insulating Materials held meetings at the Wardman Park Hotel.

Steel

Six proposed new specifications were approved by Committee A-1 on Steel for reference to letter ballot of its some 229 members. While all are important, four are particularly significant covering low-alloy structural steel, light gage structural quality carbon steel sheets (two specifications), and extensive new requirements for alloy and carbon steel blooms, billets, and slabs for forgings. Of the two other specifications, one covering hot-worked high-carbon steel tie plates will be offered for immediate adoption as standard, and the other covering ring and disk forgings is to be issued as tentative.

The new specifications for low-alloy structural steel cover material with a composition conducive to weldability, intended primarily for use as main stress-carrying material of structural members and are limited to material not over 2 in. in thickness. The maximum permissible carbon in ladle analysis is 0.20 per cent (check analysis, 0.22) and the maximum manganese is 1.00 (check analysis, 1.05). The manufacturer is to use alloying elements which, combined with the carbon, manganese, and sulfur limits, will produce the required physical properties. A note indicates that if steel is purchased for welding, the suitability of the chemical composition shall be based upon evidence acceptable to the purchaser. The tensile strengths required range from 63,000 to 70,000 psi., depending upon the thickness range and the relatively high yield points which characterize various compositions coming in this class range from 40,000 for material over $1\frac{1}{2}$ in. to 2 in., incl., in thickness to 50,000 psi. for thinner material. Many of these types of steels have come on the market in recent years.

Another important development is the work on welding

of structural steels. Agreement was reached at the meeting on changes which might be set up in the Standard Specifications for Steel for Bridges and Buildings (A 7 – 39) to cover the weldability of this material. One important problem has been to provide chemical limits, particularly for carbon and manganese, as well as physical properties which are now given. The proposed revisions are to be referred to various parties for study and comment, in anticipation that later specific action of the Society may be requested.

The two new specifications covering steel sheets were preceded by intensive work on the part of manufacturers in correlating various data and information so that the requirements could be based upon latest practices. There have been persistent demands that Committee A-1 establish quality standards for hot-rolled sheets to cover material not included in the various plate specifications. One specification covers material 0.2499 and 0.1874 in. to 0.0478 in., incl., in thickness; the second covers material from 0.0477 down to 0.0225 in. Each specification sets up four grades of material. One is a commercial grade which is subject to a bend test only. For the heavier gage material the tensile strength of the three grades, minimum, psi. is 48,000, 52,000, and 55,000; for the lighter gage the figures are 45,000, 50,000, and 52,000, respectively.

The proposed new tentative specifications for carbon steel and alloy steel blooms, billets, and slabs for forgings are intended to supersede when adopted as standard the existing standard A 17 – 29. Many controversial points have been discussed and settled in a section of Subcommittee VI. A note in the specifications indicates that they cover material suitable for forgings covered by four other A.S.T.M. specifications; namely, A 235, carbon-steel forgings for general industrial use; A 236, carbon-steel forgings for locomotives and cars; A 237, alloy-steel forgings for general industrial use; and A 238, alloy-steel forgings for locomotives and cars. Over 30 types and grades of material are covered by chemical requirements with carbon and manganese ranges specified as well as the various alloying elements, chromium, nickel, vanadium, and molybdenum.

In justification of the recommendation that proposed new specifications covering hot-worked high-carbon tie plates be accepted by the Society in 1941 for immediate adoption as a formal standard, it was pointed out that this specification was essentially in agreement with requirements in existence for some time as issued by the American Railway Engineering Association, but that reference by various organizations (including export business) to other A.S.T.M. standards of quality to cover this material made it very desirable that there be a specific standard for this purpose.

The proposed specifications for carbon-steel and alloy-steel ring and disk forgings list nine classes of carbon steel material and six of alloy steel. The carbon steel materials are classified according to heat treatment and physical properties, the material ranging from untreated to quenched and tempered, with tensile strength ranges from 47,000 to 90,000 psi., depending upon treatment and size classifications and yield points ranging from 25,000 to 55,000 psi. The six grades of alloy material in treatment from annealed to normalized, quenched and tempered have minimum tensile strength values of from 80,000 to 125,000 psi. The yield point ranges are 50,000 to 105,000 psi.

Another of the recommendations to be offered this year is to adopt as standard the Tentative Specifications for Carbon-Steel Castings Suitable for Fusion Welding for Miscellaneous Industrial Uses (A 215 – 39 T). The subcommittee on steel castings held a most interesting meeting with specially invited representatives from the Army, Navy, and Federal Specifications Board to have a discussion on methods of cooperating along lines of simplification of specification requirements.

Cast Iron

Among the interesting reports submitted to Committee A-3 on Cast Iron by the subcommittee chairmen were those on microstructure and impact testing and on methods of testing. The committee on microstructure which has been working jointly with the American Foundrymen's Association committee is reporting a recommended method for classification of graphite in gray iron which Committee A-3 is submitting to Committee E-4 on Metallography for review.

Subcommittee XV on Impact Testing reported that it had approved details of construction for a drop test machine and will submit for publication a recommended practice for both types of impact test, one using a Charpy test on a properly prepared broken transverse test bar and the other using a repeated drop test.

The subcommittee on methods of testing has been given a new assignment, namely, to act as a clearing committee on details of all new test methods which are brought forward from time to time by the various subcommittees. In line with this the committee reached agreement on standardized procedures for carrying out the following tests on cast iron: compression, shear, and torsion. These methods are to be covered in one document. One of the matters discussed at the meeting was the desirability of securing more widespread familiarity with standardized testing procedures.

Corrosion of Iron and Steel

Subcommittee III on Inspection of Annapolis Tests in its report to Committee A-5 stated that it is still continuing the exposure tests of black uncoated iron and steel sheets started in 1915 at Annapolis, Md. An inspection of the sheets was made last October and several new failures noted which will be covered in the 1941 annual report. During the past year, the Navy Department found it necessary to use the site on which the test racks were located which required their removal to a new location adjacent to the old site.

Subcommittee V on Total Immersion Tests has in its charge the test specimens of riveted plates which have been removed at Portsmouth, N. H., and those at Key West which will be removed shortly. A final inspection of these plates and a report will be made, but not in time to be included in the 1941 annual report. The pipe specimens, including both low and high copper content, removed last spring have been cleaned and examined. A report on these prepared by V. V. Kendall is now being edited by the subcommittee and will be presented this

year. The exposure tests in sea water of all sheet, pipe, and plate specimens are now completed. A final report covering all the work of the subcommittee to date will be prepared some time this year.

Subcommittee VI on Specifications for Metallic-Coated Products proposed to recommend the adoption as standard of the two tentative specifications covering zinc-coated iron or steel wire strand (A 122) and zinc-coated steel wire strand (A 218).

B. J. Barmack, Commonwealth Edison Co., has been appointed chairman of a subgroup to prepare new specifications for zinc-coated iron and steel hardware materials. The organization of this section is actively under way at the present time.

The 1941 report of Subcommittee VIII on Field Tests of Metallic Coatings will cover principally the atmospheric exposure tests on zinc-coated wire materials including straight wire, woven wire fencing, barbed wire and chain-link fencing. These materials have been exposed since 1936 at eleven locations. Corrosion of some of the materials has now progressed far enough at several locations to permit drawing some preliminary conclusions. It was found necessary this past year to move the test rack at Key West because the Navy required the use of the land on which our rack was located. The rack and all test materials were relocated on a satisfactory site made available on the Army reservation at Key West.

The exposure tests on zinc—and other protective coated hardware samples have been completed on a large majority of the samples at all locations. The materials still remaining under test consisting principally of hot-dip zinc and aluminum-coated samples are to be assembled on a section of the test rack at each location and the test on these materials continued.

Investigation of the unusual failures of zinc coatings on sheets at Key West mentioned in last year's subcommittee report is still continuing. Several sheet specimens showing this type of failure will be removed from the racks at Key West for closer study and possibly microchemical analysis in the laboratory of the corrosion products.

The foregoing unusual failure of zinc coatings and other peculiar failures under certain service conditions has suggested the possibility of a correlation between such failures and the chemical composition of the zinc coating on the failed specimens. Subcommittee VIII has already made a preliminary study of the analytical problems involved and has appointed a section to work with the National Bureau of Standards in developing proper analytical methods before proceeding further in their analysis of the zinc coatings on the materials exposed.

Magnetic Properties

The adoption as standard is to be recommended of the new definitions for polarizing magnetizing force, incremental magnetizing force, polarized induction, incremental induction, and incremental core loss, for inclusion in the Standard Definitions of Terms, with Units and Symbols, Relating to Magnetic Testing (A 127 – 39).

The subcommittee on direct current test methods discussed the results that have been obtained on studies on two high coercive force magnet steel bars which have been checked by several cooperating laboratories. Also under consideration is the preparation of a method for the measurement of permeability of the so-called nonmagnetic steel materials.

J. C. Moore, Sinclair Refining Co., and Anthony Skett, American Gum Importers Assn.

The subcommittee on alternating current test methods presented the results from six cooperating laboratories with a half-length Epstein sample for both core loss and permeability tests. Core loss values were obtained at 60 cycles over the flux density range of 4000 to 16,000 gausses or higher. Alternating current permeability values were obtained for approximately 10,000 gausses or higher. The data obtained will be reviewed by the committee and should be of value in arriving at a standard method.

The subcommittee also presented results of a round-robin test by seven cooperating laboratories on a study of conditions of combined alternating and direct magnetization on half-length Epstein samples. These properties are of chief interest in connection with core materials for use in transformers connected to thermionic tubes.

A revision for 1941 adoption was approved in the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 39) providing for the use of a new permeameter developed at the National Bureau of Standards known as the "High H" permeameter for use in place of the modified isthmus method.

The committee also acted to recommend the adoption of the Tentative Method of Test for Measuring Interlamination Resistance and Lamination Factor of Iron and Steel (A 34 – 40 T).

Malleable-Iron Castings

One of the important subjects discussed by Committee A-6 was the demand for quality specifications covering particular applications of the materials. As a result the subcommittee on cupola malleable iron was asked to start the formulation of suitable standard requirements covering malleable fittings. The subgroup concerned with pearlitic and alloy malleable iron plans, in line with this same general subject is to consider the possibility of separate standardized specifications covering the various types of this material as manufactured.

An editorial change in line with latest concepts of the properties of malleable iron was approved by which the reference to yield point in the various standards will be changed to yield stress. This would become effective probably in 1942 when the next Book of A.S.T.M. Standards is issued.

Among the functions of the various A.S.T.M. technical committees is the sponsoring and developing of informa-

(Continued on page 61)

A Simple Flexure-Testing Machine for Plastics

By G. H. Brother,[1] W. C. Suttle,[1] and L. L. McKinney[1]

In taking up the study of testing of plastics at the U. S. Regional Soybean Industrial Products Laboratory, it was felt that the flexure testing machines readily available were too heavy and more expensive than necessary for the testing of plastics. Therefore, a simple machine was developed for this test in accordance with the specifications[2] of the American Society for Testing Materials.

Among possible designs were:

1. A machine using an ordinary platform scale, converted, as a dynamometer for the test.
2. Use of a calibrated ring as a dynamometer.
3. Use of a calibrated spring as a dynamometer.
4. Use of a pendulum-type dynamometer.

It was found that a machine built with a pendulum-type dynamometer embodied most of the favorable features of the other types considered and at the same time eliminated a majority of the objectionable features.

Description of the Machine

Figure 1 shows the machine in operation. Essentially it consists of a 3-point support for the test specimen, hung from a drum connected to a recording device and the pendulum dynamometer. The load is applied to the specimen from below through a gear-screw system. This is designed to give a crosshead speed of 0.050 in. per min. while the machine is running idle (A.S.T.M. Standard Methods of Testing Molded Materials Used for Electrical Insulation (D 48 – 39)[2]). The load is proportional to the sine of angle α, the angle of deflection of the pendulum dynamometer from neutral, and is recorded by a pointer traversing a dial (see Fig. 3).

Referring to Fig. 2, which is an assembly drawing of the machine, the principles of operation can be followed readily. The power from the motor-reducer, *1*, is conveyed from the motor shaft through an 8-mm. roller chain, *2*, to a worm, *3*, which transmits the power to the gear train. The pinion, *4*, has a slot in the hub which engages a pin inserted through the pinion shaft and fits its shaft loosely enough that it may be raised or lowered forming a simple positive clutch when engaged with the pin. The main screw gear, *5*, drives the power screw, which has 10 threads per inch on a $^3/_4$-in. shaft and is driven at $^1/_2$ r. p. m. to meet the A.S.T.M. requirements[2] that the crosshead speed shall not exceed 0.050 in. per min.

The test specimen rests on supports 4 in. apart, and the load is applied midway between them. The supports are rounded to a $^1/_8$-in. radius to comply with A.S.T.M. requirements.[2] The specimen support is connected to the pendulum shaft, 7, by a steel band which unwinds from a drum, turned integral with the shaft, as the load is applied to the specimen. As the load on the specimen increases, it produces a moment about the axis of the pendulum shaft which is neutralized by the moment produced by the pendulum, *8*, as it swings to the left. The angular displacement of the pendulum shaft is amplified by the lever, *9*, and transmitted to the load-indicating mechanism illustrated in Fig. 3.

To simplify running the crosshead up and down by hand, the pinion *4* is disengaged, and the hand crank *10*, which is on a sliding mount, is moved to the right until the worm on the crank shaft engages the wheel on the power screw *6* which can be run up or down at will. When the final adjustment is made, the crank is disengaged and the pinion is dropped into place with the pin and its mating gear.

The load P (Fig. 3) produces a moment Pr about the axis of the pendulum shaft 7 equal to the moment Wx. Since W and r are constants, neglecting friction which is very small because of the precision ball bearing mounting

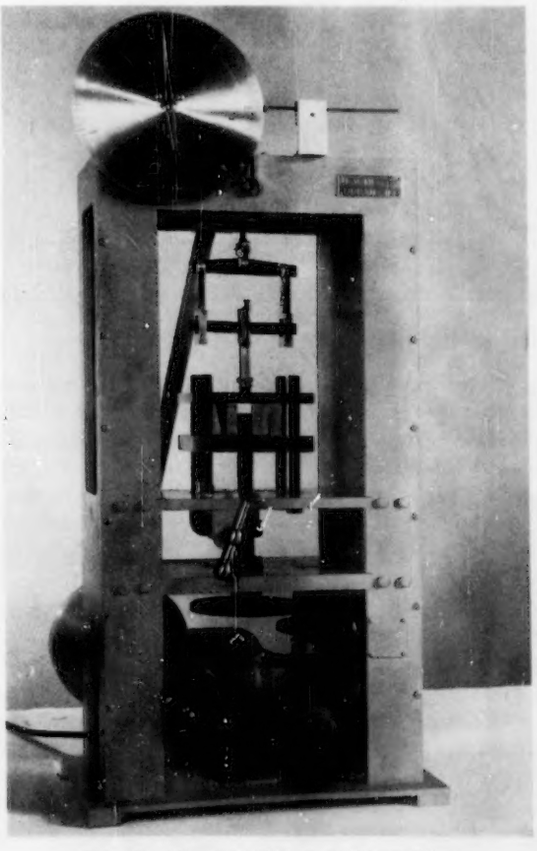


Fig. 1.—Flexural Tester in Operation.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Senior Chemist, Scientific Aid, and Associate Chemist, respectively, U. S. Regional Soybean Industrial Products Laboratory, Urbana, Ill. A cooperative organization participated in by the Bureaus of Agricultural Chemistry and Engineering and Plant Industry of the U. S. Department of Agriculture, and the Agricultural Experiment Stations of the North Central States of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

[2] 1939 Book of A.S.T.M. Standards, Part III, p. 247.

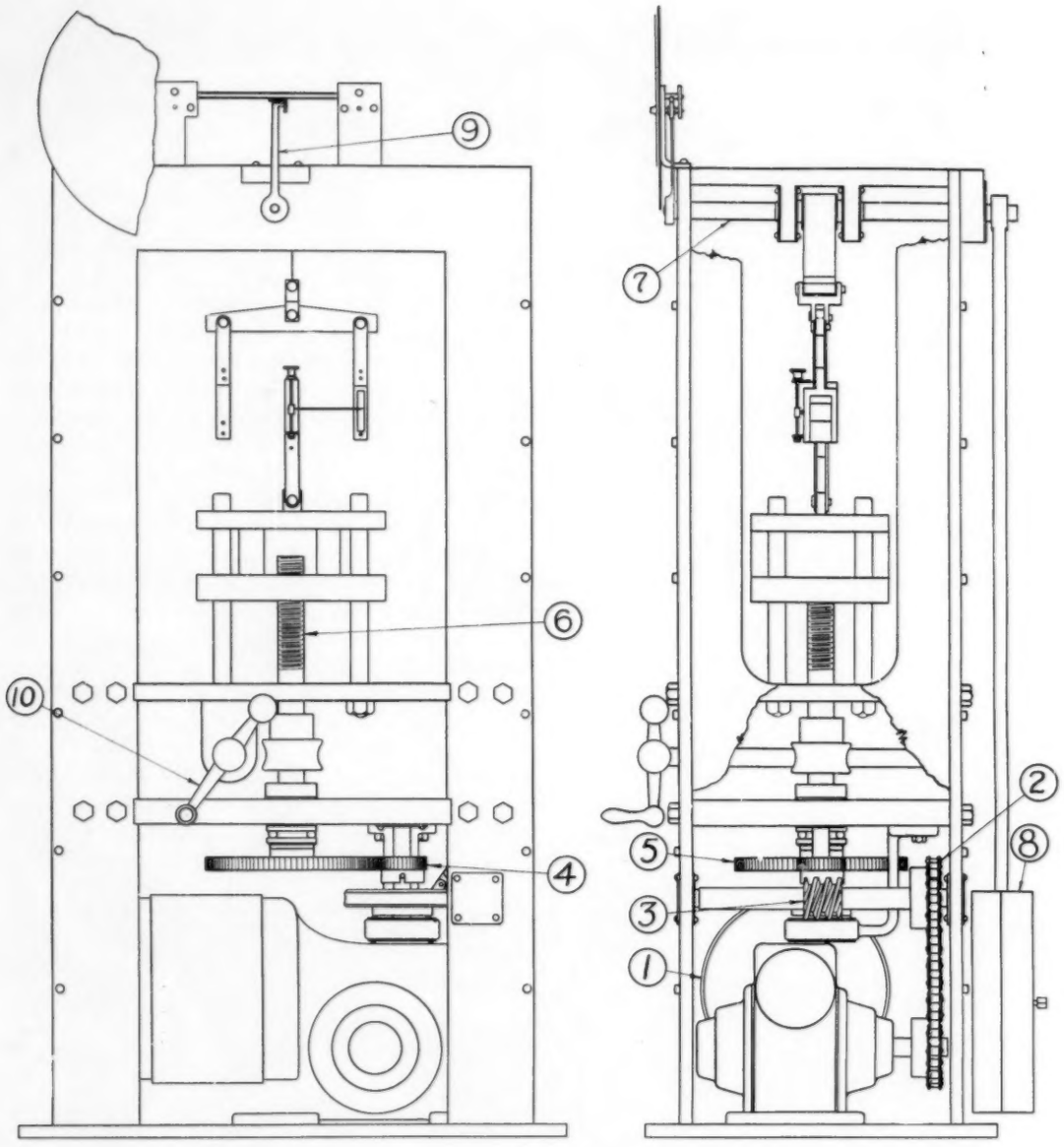


Fig. 2.—Assembly Drawing of Flexure Tester.

of the pendulum shaft, the load P is proportional to the sine of the angle α $\left(P = \frac{WR}{r} \sin \alpha\right)$.

The angle α can be found for the maximum load P which governs the selection of the pinion *11* in order that the indicator *12* may be made to traverse the entire range of the dial for maximum load conditions. As the pendulum swings through an angle α, the lever *9* moves through the same angle. It engages a projection soldered to the $^1/_8$-in. 48-pitch rack *13* and causes it to be displaced to the right. The rack rides freely over two $^1/_2$ pitch diameter-48 pitch ($^1/_2$ PD-48P) pinions *11*, the left one carrying the pointer *12*.

Because of the angular displacement of the pendulum shaft, the specimen cradle *14* moves down a distance equal to S. The mid-span support *15* moves down a distance S plus the deflection of the test specimen plus the distance the supports crush into the specimen. The latter correction cannot be accounted for in the machine itself. However, for deflection measurements the distance S can be eliminated by equipping the mid-span support with an adjustable pointer *16* and one of the outside supports with a scale graduated in hundredths of an inch. The relative motion of the cradle and center support, which is equal to the deflection and the distance the supports crush into the specimen, can be read from the scale.

The machine is small and compact but rugged in design. It is 35 in. over-all in height and rests on a $10^1/_2$ by 16-in. base. It is fabricated entirely of standard parts and materials. The main frame is of $^3/_8$-in. hot-rolled steel plate with heavier material introduced where necessary. Since the machine is used in a chemical laboratory, all parts not to be painted were made of 18 per cent chromium, 8 per cent nickel steel to prevent corrosion. All bearings are precision ball, and all gears, racks, sprockets, and chains are standard.

Calibration

The machine was calibrated by the dead-weight method as shown in Fig. 4. A bar, *1*, and weight hooks, *2*, were made and their weight adjusted to within 0.01 lb. of 10 lb. The weights, *3*, were laboratory calibration weights and

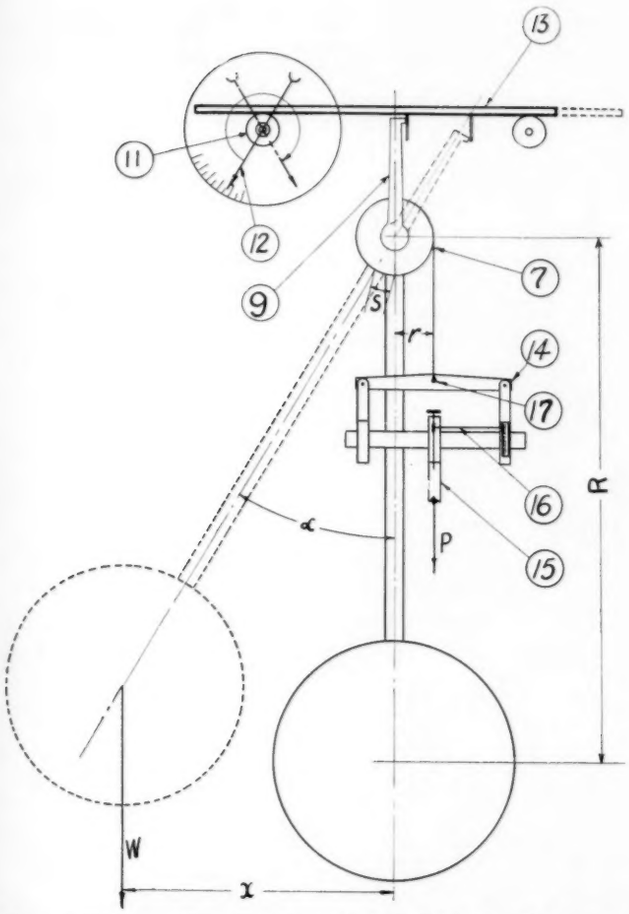


Fig. 3.—Diagram Showing Operation of Pendulum Dynamometer and Load-Indicating Mechanism.

were accurate within 0.01 lb. of 5 lb. As the weights, *3*, were added in 10-lb. increments, a record of the pointer travel was made on paper fastened to the dial, *4*. Five trials were made and the average taken. The 10-lb. divisions were then divided geometrically into 2-lb. increments and reproduced on the stainless steel dial of the machine. The 2-lb. divisions were approximately 2 deg. apart of $^1/_8$ in. on the 8-in. dial.

A.S.T.M. methods[2] require that a machine be accurate to within 1 per cent for the lowest load for which it is used. In the five trials, the spread on the dial was no more than $^1/_4$ lb. The dial may therefore be read to an accuracy within 1 per cent for all loads over 25 lb.

It should be noted that if the calibration of the dial is to be uniform, lever *9* must extend in the same straight line of the pendulum arm as shown in Fig. 3. In this way the linear displacement of rack *13* is proportional to sine α and in turn to load *P*.

Discussion

This machine is convenient for the flexural testing of plastics because of its small size and comparative light weight, which is only about 230 lb. It can be moved easily from one part of the laboratory to another, and use of the pendulum dynamometer makes balancing after moving unnecessary. All that is necessary to get accurate readings is that the pointer be brought to zero after it is moved. The pointer is so arranged that when the bar breaks, the pendulum is free to swing, leaving the pointer recording the breaking load.

The dial is calibrated to 350 lb., which is a practical limit in the testing of $^1/_2$-in. plastic test specimens. However, the machine has a capacity of 500 lb., and if desirable, the full capacity may be used by increasing the size of the pendulum bob.

Results Obtained

The well-known flexure formula, $S = \frac{Mc}{I}$, was developed for pure bending, and is limited to bars with a symmetrical cross-section.

Beyond the elastic range of the specimen the above formula becomes inexact, since Hooke's law no longer holds, and a value computed by that formula is a nominal stress. The nominal stress under the maximum load in a test to rupture is known as the modulus of rupture and is an index of ultimate static strength of the material. Modulus of rupture is commonly known as flexural strength[2] or transverse strength.

By substituting the dimension of a rectangular test bar in the equation, it becomes[3]:

$$S_r = \frac{M}{I/c} = \frac{PL/4}{bh^2/6} = \frac{3}{2}\,\frac{PL}{bh^2}$$

where S_r = modulus of rupture, in pounds per square inch,
P = load on specimen, in pounds,
L = distance between supports, in inches,
b = thickness of bar, in inches,
h = height of bar, in inches,
M = bending moment at mid-span, in pounds,
I = moment of inertia about neutral axis, and
c = distance from neutral axis to remotest point of section.

[3] F. B. Seely, "Resistance of Materials," pp. 81–84, 116, 128, John Wiley and Sons, Inc., New York, N. Y. (1935).

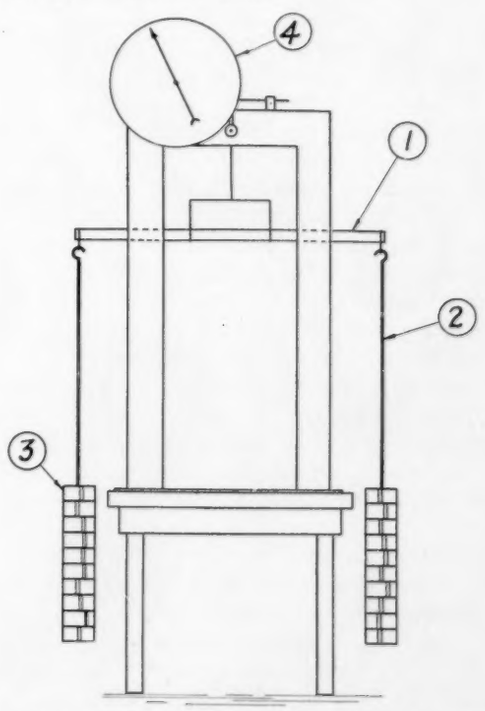


Fig. 4.—Diagram Showing Method of Calibration of Flexure Tester.

When the test for modulus of rupture is being run, loads corresponding to equal increments of deflection can be recorded and a load-deflection curve drawn. Then by the use of Hopkins'[4] equation which again is a variation of the formula for deflection at the middle of a simple beam loaded at the mid-span, the modulus of elasticity may be calculated. Modulus of elasticity obtained by an apparatus of this nature is not reliable owing to the crushing of the specimen at the supports.

In order to obtain some idea of how results from this machine would check with those from flexure testing machines now in use, three commercial phenolic molding powders were examined. Regulation test bars, 1/2 by 1/2 by 5 in., were molded at 350 F. and 2000-psi. pressure. They were conditioned 24 hr. at 50 C., cooled to room temperature, and broken in the machine. Three curing times were used, 10, 15, and 20 min. Three bars were tested for each, and the average recorded in Table I. The range, as furnished by the manufacturer, is also given for each.

[4] I. L. Hopkins, "A Useful Convention for Calculating the Modulus of Elasticity and a Nomogram to Help in Computing the Elastic Modulus and the Flexural Strength," ASTM BULLETIN, No. 98, May, 1939, p. 29.

TABLE I.—RESULTS OF FLEXURAL STRENGTH TESTS, PSI.

Plastic	10-min. Curing	15-min. Curing	20-min. Curing	Range Given by Manufacturer
Phenolic No. 1	11 110	10 770	11 110	12 000 to 9000
Phenolic No. 2	11 550	10 710	11 530	11 500 to 9000
Phenolic No. 3	6 830	6 610	6 830	10 209 to 7800
Soybean-phenolic (3-3-2)	8 150	7 720	7 620	.....

There is also included a sample of soybean-phenolic molding powder, made up of 3 parts (by weight) of formaldehyde-hardened soybean meal, 3 parts phenolic resin, and 2 parts wood flour. It will be seen that this compares reasonably well with the regular phenolics at 10-min. cure, being weaker than two but stronger than one. With longer cures the soybean-phenolic material becomes progressively weaker. This is probably owing to the breaking down of protein at the high temperature (350 F.).

Acknowledgment:

The authors wish to express their appreciation to W. J. Putnam and H. F. Moore of the University of Illinois, who so ably advised them in the design and description of this machine.

Abbot A. Hanks, Inc., Celebrates Seventy-fifth Anniversary

THE FIRM OF Abbot A. Hanks, Inc., San Francisco, Calif., which has been affiliated with the Society for almost 25 years as a company member is celebrating this year its Seventy-fifth Anniversary of continuous business.

Henry G. Hanks, who originally established the firm, came to California in 1852, first engaging in the manufacture of fine chemicals, reagents, and paints. He built one of the first borax refineries in this state, taking crude borax obtained from the borax springs at Clear Lake, Calif., and producing a refined product. His interest was always centered in metals and minerals and resulted in his establishing one of the earliest custom chemical and assay laboratories in California, in 1866. He was California's first state mineralogist.

In 1887 his son, Abbot A. Hanks, joined him in business and in 1896, upon retirement of the older Hanks, the business was transferred to him and placed in his name.

In 1924 the firm was incorporated, at which time an interest was acquired in the business by a number of the older members of the staff.

In pace with technical developments, the business expanded to include engineering inspection, materials investigation and testing, soil testing and metallurgical investigations.

One of the important features of the business is the sampling and testing of cement, examination and tests of concrete aggregates and determination of concrete mixes and making examination of existing concrete in structures by core cutting or other means. A force of trained inspectors covers mill, shop, and erection inspection of structural steel for buildings, bridges, and other structures and supervises the mixing and placing of concrete, as well as the inspection and tests of untreated and treated lumber and piles.

Besides maintaining established laboratories, it specializes in the sampling, supervising, weighing, and reporting shipments of ores, minerals, metals, and metal products for general inorganic determinations, whether in the field, at smelter, warehouse, or shipside and renders control and umpire assays.

H. D. Imrie, who was associated with Mr. Hanks for many years, is President and a director of the company; T. P. Dresser, Jr., secretary of the A.S.T.M. Northern California District Committee, and a member of Committee D-18 on Soils for Engineering Purposes and several of its subcommittees, and representative of the company's membership in A.S.T.M., is Chief Engineer and a director; Prentiss T. Bee, who represents his company on Committee D-19 on Water for Industrial Uses, is a director; and J. L. Martel is Vice-President and director of the company.

Elections to A.S.A. Board of Directors

ON NOMINATION OF the Society, Jerome Strauss, Vice-President, Vanadium Corporation of America has been reelected for a term of three years as a member of the Board of Directors of the American Standards Association. In addition to Mr. Strauss two other men were reelected: namely, Carl Breer, Executive Engineer, Chrysler Corp., and John C. Parker, Vice-President, Consolidated Edison Company of New York. Announcement was made also that S. Bruce Black, President, Liberty Mutual Insurance Co., will serve as a member of the Board of Directors representing the National Association of Mutual Casualty Companies.

Saturation Coefficient Values for Brick by the Absorption-Boiling and the Absorption-Porosity Methods

By R. T. Stull[1] and Paul V. Johnson[1]

EDITORIAL NOTE.—In an investigation at the National Bureau of Standards on the weather-resisting properties of zinc-flashed and glazed brick, the resistance of the brick to frost action is correlated with both the absorption-boiling and the absorption-porosity saturation coefficients. Table III in the accompanying paper gives data obtained from one series of brick included in the former investigation. The brick of series 1 and 2 (Tables I and II) are not glazed, but were included with series 3 to show extreme differences between the saturation coefficients as obtained by the two different methods. The absorption-porosity ratio shows substantially the true relation between the pore-filled volume and total pore volume of the brick and inasmuch as this is not always shown by the absorption-boiling ratio, the former ratio should be more reliable for predicting the behavior of a brick in the freezing-and-thawing tests.

THE SOCIETY'S tentative specifications for building brick[2] specify 0.80 as the maximum limit for the saturation coefficient for bricks subjected to considerable moisture and to temperatures below freezing in places such as foundations and parapets. For bricks subjected to a moderate amount of moisture and to temperatures below freezing, such as in the walls of buildings, the maximum limit of 0.85 is specified.

The saturation coefficient is generally defined as the ratio of easily filled pore space to total fillable pore space. In the specifications[2] and as described in the corresponding methods of test,[3] the saturation coefficient is the ratio of absorption by 24-hr. cold immersion to absorption by 5-hr. boiling. Each of these two absorptions is expressed as percentage of the dry weight of the brick and in this paper the ratio is designated as C/B.

The saturation coefficient, C/B, is the same in value as the ratio of the volume of water absorbed by 24-hr. immersion to the volume of the pores filled with water after boiling. Therefore, B minus C, expressed in volume, should represent the volume of air available in the pores to serve as a cushion to relieve pressure caused by expansion during freezing.

However, the water saturation method for obtaining the C/B coefficient may be in error due to the fact that some of the pores may not be completely filled with water on boiling and cooling. This is especially true of the micropores into which the water does not enter when boiled under atmospheric pressure.

A method frequently used for determination of porosity consists of soaking the specimen in a liquid by boiling under partial vacuum and cooling. The porosity is the ratio of the volume of the liquid absorbed to the bulk volume of the specimen expressed in per cent. Washburn and Bunting[4] show that the percentage porosity obtained by the water soaking method for a stoneware clay fired to pyrometric cone No. 10 (equivalent to approximately 1330 C.), was 0.8 less than that obtained by the gas expansion method, and for a red-burning clay fired to pyrometric cone No. 03, (equivalent to approximately 1080 C.), the percentage porosity was 5.4 less.

Instances have been encountered where bricks showing C/B ratios above 0.90 have withstood over 50 cycles of freezing and thawing without showing signs of failure. Inasmuch as saturation by boiling may not fill the pores completely, the C/B values may be higher[5] than those of W/V where W is the percentage volume of water absorbed by 24-hr. immersion, and V the percentage porosity (determined by the air expansion method), exclusive of the sealed pores.

The results obtained for both the C/B and W/V values determined on three different groups of bricks are given in Tables I, II, and III. The bricks of group 1 (Table I) are a miscellaneous lot made of nondeaired clays and were selected at random from samples corresponding to those tested by McBurney and Eberle for freezing and thawing of building brick.[6] Those of group 2 (Table II) are nondeaired soft-mud bricks from a Connecticut producer, and those of group 3 (Table III) are buff brick made of a "nonrefractory" deaired fire clay from an Ohio producer.

In the tables:

C = weight of water absorbed by 24-hr. immersion, expressed in percentage of the weight of the dry brick;

B = weight of water absorbed by 5-hr. boiling and cooling (after 24-hr. immersion), expressed in percentage of the weight of the dry brick;

W = C, converted to volume percentage of the bulk volume of the brick; and

V = porosity (exclusive of sealed pores) in percentage of the bulk volume of the brick.

In Table I, the results obtained for the miscellaneous lot of bricks indicate that the differences between the C/B and W/V values for individual bricks range from zero to 0.055. With the exception of brick *e* these differences are negligible since they are less than the range in reproducibility of the absorption measurements.

The results obtained for the soft-mud Connecticut bricks of group 2 (Table II) indicate differences between the C/B and the W/V saturation coefficients ranging from 0.150 to 0.212. All bricks of the series, according to the

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[1] Senior Technologist, and Associate Technologist, respectively, National Bureau of Standards, Washington, D. C.

[2] Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 – 40 T), 1940 Supplement, Part II, to Book of A.S.T.M. Standards.

[3] Standard Methods of Sampling and Testing Brick (Modulus of Rupture, Compressive Strength, Absorption) (C 67 – 39), 1939 Book of A.S.T.M. Standards, Part II, p. 104.

[4] E. W. Washburn and E. N. Bunting, "Porosity; VI. Determination of Porosity by the Method of Gas Expansion," *Journal*, Am. Ceramic Soc., Vol. 5, No. 2, pp. 112–129 (1922).

[5] *Technical News Bulletin, No. 234*, Nat. Bureau Standards, October, 1936, p. 86.

[6] J. W. McBurney and A. R. Eberle, "Freezing and Thawing Tests for Building Brick," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, Part II, p. 470 (1938).

C/B ratios, fail to meet the saturation coefficient requirements, while all bricks according to the W/V ratios would meet the requirements by safe margins. However, all specimens of this group, with the exception of No. 29, failed by breakage when subjected to 50 cycles of freezing and thawing by Method *B* of the Society's tentative method.[7]

The greatest differences between corresponding saturation coefficients obtained by the two different methods are found among bricks made from deaired, fine-grained, plastic clays such as the so-called plastic fire clays and fine-grained sedimentary clays. Small particle sizes together with the deairing treatment are conducive to the formation of large numbers of pores approaching micropores in size. The bricks of group 3 (Table III) were made from a plastic fire clay which was deaired in preparation for molding. In Table III it is seen that the differences between the corresponding C/B and W/V saturation coefficients range from 0.255 to 0.326. All of the C/B ratios are higher than the 0.85 maximum limit of the tentative specifications,[2] ranging from 0.057 to 0.100 higher, whereas the W/V coefficients are all less than the 0.80 limit of the tentative specifications, ranging from 0.116 to 0.198 lower. However, these bricks would not be rejected because of high C/B saturation coefficients since their absorptions are within the limit under which the ratio is waived.

The data presented are insufficient on which to base assumptions as to the maximum allowable saturation coefficients as defined by the W/V ratio. However, such limits in many cases will be appreciably lower than those prescribed by the C/B ratio. The results of further investigation, which is now being undertaken by the authors are necessary before such recommendations can be made.

[7] Tentative Method of Freezing-and-Thawing Test of Brick (C 67 – 39 T) 1939 Book of A.S.T.M. Standards, Part II, p. 930.

TABLE I.—SATURATION COEFFICIENTS AND OTHER PROPERTIES OF MISCELLANEOUS LOT OF NONDEAIRED BRICKS.

	Brick *a* Dry-Press (Sandy Clay)	Brick *b* Stiff-Mud, Side-Cut (Shale)	Brick *c* Soft-Mud (Clay)	Brick *d* Stiff-Mud, Side-Cut (Clay)	Brick *e* Stiff-Mud, End-Cut (Clay)	Average
C	13.9	14.3	13.4	15.0	15.4	14.4
B	16.8	17.9	19.8	16.9	17.4	17.8
W	25.6	26.0	23.8	28.6	27.9	26.4
V	31.4	33.0	36.0	32.2	33.6	33.2
C/B	0.827	0.799	0.677	0.888	0.885	0.815
W/V	0.815	0.787	0.661	0.888	0.830	0.796
C/B − *W/V*	0.012	0.012	0.016	0	0.055	0.019
100 *WB/VC*[a]	98.5	98.5	97.6	100.0	93.8	97.7
Failed, cycles	[b]	43	[b]	24	4	

[a] Percentage of total pore space filled by boiling.
[b] Bricks *a* and *c* withstood 50 cycles without loss.

TABLE II.—SATURATION COEFFICIENTS AND OTHER PROPERTIES OF NONDEAIRED, SOFT-MUD (CLAY) BRICKS FROM CONNECTICUT.

	Brick 25	Brick 26	Brick 29	Brick 33	Brick 42	Average
C	15.6	15.0	12.9	13.6	15.0	14.4
B	17.4	15.6	14.4	14.2	16.5	15.6
W	27.4	27.1	23.7	25.0	26.6	26.0
V	36.7	34.9	32.9	33.5	36.0	34.8
C/B	0.897	0.962	0.896	0.958	0.909	0.923
W/V	0.747	0.776	0.720	0.746	0.739	0.747
C/B − *W/V*	0.150	0.186	0.176	0.212	0.170	0.176
100 *WB/VC*[a]	83.2	80.7	80.4	77.9	81.3	80.9
Failed, cycles	15	49	[b]	50	26	

[a] Percentage of total pore space filled by boiling.
[b] Brick 29 withstood 50 cycles with less than 1 per cent loss in weight.

TABLE III.—SATURATION COEFFICIENTS AND OTHER PROPERTIES OF DEAIRED, STIFF-MUD (FIRE CLAY) BRICKS FROM OHIO.

	Brick FC-1	Brick FC-2	Brick FC-4	Brick FC-8	Brick FC-9	Brick FC-10	Brick FC-13	Brick FC-16	Brick FC-18	Brick FC-20	Average
C	3.2	2.9	3.3	3.0	3.8	3.1	2.9	3.4	3.2	3.5	3.2
B	3.4	3.1	3.5	3.2	4.0	3.4	3.2	3.7	3.4	3.8	3.5
W	7.8	7.2	8.0	7.4	9.1	7.7	7.3	8.4	7.8	8.6	7.9
V	11.4	11.5	12.4	12.1	14.3	11.9	11.3	13.8	12.1	12.9	12.4
C/B	0.942	0.936	0.943	0.938	0.950	0.912	0.907	0.919	0.941	0.922	0.914
W/V	0.684	0.626	0.645	0.612	0.636	0.647	0.646	0.608	0.645	0.667	0.637
C/B − *W/V*	0.258	0.310	0.298	0.326	0.314	0.265	0.261	0.311	0.296	0.255	0.277
100 *WB/VC*[a]	72.7	66.9	68.5	65.3	67.0	71.0	71.3	66.2	68.4	72.4	69.7
Cycles	All bricks have gone 170 cycles without loss										

[a] Percentage of total pore space filled by boiling.

1941 Heating, Ventilating, Air Conditioning Guide

RECENTLY PUBLISHED is the *1941 Heating, Ventilating, Air Conditioning Guide* issued by the American Society of Heating and Ventilating Engineers. This nineteenth edition of this annual publication follows in style and format previous volumes but has a number of important modifications and additions.

The technical data section of reference material on the design and specification of heating, ventilating, and air conditioning systems covers some 800 pages with 46 chapters being rearranged into seven main sections as follows: Principles (thermodynamics, physiological); Heating and Cooling Load Calculations (heat transmission, tables, air leakage, heating and cooling load); Combustion and Utilization of Fuels; Steam and Hot Water Heating (heating boilers, piping, hot water heating systems, district heating, pipe, fittings, welding); Air Heating, Cooling and Conditioning (warm air systems, central systems, unit heaters, cooling, spray equipment, air pollution, sound control, etc.); Automatic Controls, Instruments and Motors; Special Applications and Miscellaneous (air conditioning and disease, transportation and industrial air conditioning, drying systems, etc.).

A new chapter on Thermodynamics of Air and Water Mixtures has been included. A large number of authorities in the industry and members of the society have contributed and an effort has been made to include authoritative new data which are constantly being developed in this rapidly growing field, a considerable amount of data coming from the A.S.H.V.E. Research Laboratory in Pittsburgh.

An important part of the Guide is the Catalogue Data Section, in which much useful information has been supplied by the various manufacturers, and this section has been grouped into subdivisions for convenience in locating data. In addition to the technical data section there is given a membership list of the A.S.H.V.E. Two complete indexes cover the equipment and catalogue data sections.

The handbook is available at $5.00 with a limited number of thumb-indexed copies at $5.50 each.

An Immersion Test for Rubber Compounds*

By B. S. Garvey, Jr.[1]

SYNOPSIS

A die-cut specimen exactly 100 mm. long and 1.6 mm. wide is immersed in liquid and the change in length, ΔL, read without removing the sample from the tube. The corresponding percentage increase in volume, ΔV, is read directly from a prepared table. The operation is fast and simple and there are no calculations.

Results of tests are given and the new method is compared with the present A.S.T.M. method. The two methods give results of comparable accuracy.

With good swelling agents ΔL is sensitive to calender grain. The test is therefore useful as a measure of grain effects.

THE PROCEDURE described here was developed to determine the comparative swelling effect of a variety of liquids on a variety of compounds. To carry out such a program by the regular A.S.T.M. method[2] would be very expensive because of the large number of weighings and calculations.

DESCRIPTION OF PROCEDURE

Test Specimen:

The test specimen is 100 mm. long and 1.6 mm. wide. The thickness may vary from 0.6 mm. to 3.0 mm. With a standard A.S.T.M. tensile sheet[3] the thickness is 1.9 mm. (0.075 in.). The samples can be die cut from any sheet of stock more than 100 mm. long and 2 mm. wide. The best procedure is to cut two strips at right angles to each other from a tensile sheet and to take the average swell of the two strips.

An experienced operator can cut such samples to within 0.5 mm. of the exact length. With an inexperienced operator the variation may be as much as 1.0 mm. It is desirable, therefore, to check the original length of the sample and make a correction to the increase in length, ΔL. The correction to the original length and separate calculation of volume change, ΔV, based on the corrected length is not necessary because the correction to ΔV is too small.

Immersion Tubes:

The immersion tubes are approximately 250 mm. long and are sealed at one end. They can be quickly and easily made from 10-mm. Pyrex tubing. In the bottom of each tube is placed a piece of 7.5-mm. glass rod about 2 cm. long with square cut ends. This rod is for convenience in holding the tube while making readings.

These tubes can be closed with small corks or rubber stoppers if the vapor pressure of the liquid is not too high. If the tubes are to be heated, a small breather hole should be made so that the corks will not be blown out by the expanding air. Under conditions where the vapor pressure will be high the tubes should be cooled and sealed off in a blast lamp.

Identifying numbers can be put on the corks or on aluminum tags wired to the tubes.

While 10-mm. tubes are preferred, other sizes from 8

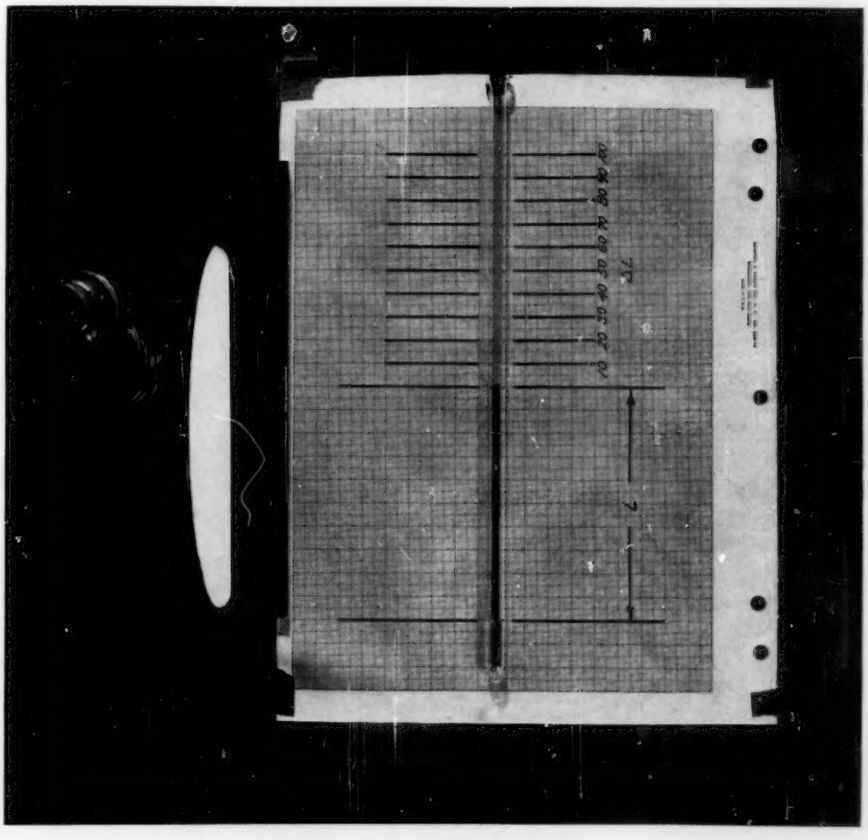

Fig. 1.—Reading Table.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

* Presented before the Rubber Division of the American Chemical Society, Detroit, Mich., Friday, September 13, 1940.

[1] Chemical Research Laboratories, The B. F. Goodrich Co., Akron, Ohio.

[2] Tentative Methods of Test for Changes in Properties of Rubber and Rubber-Like Materials in Liquids (D 471 – 37 T), Section 8(*a*), 1939 Book of A.S.T.M. Standards, Part III, p. 837.

[3] A sheet made to be tested in accordance with the Standard Methods of Sample Preparation for Physical Testing of Rubber Products (D 15 – 39), 1939 Book of A.S.T.M. Standards, Part III, p. 331.

TABLE I.—RELATIONS OF ΔL to ΔV.

ΔL, mm.	ΔV, per cent	ΔL, mm.	ΔV, per cent	ΔL, mm.	ΔV, per cent	ΔL, mm.	ΔV, per cent
0.5	1.5	25.5	97.5	50.5	240.9	75.5	440.1
1.0	3.0	26.0	100	51.0	244.3	76	445.2
1.5	4.5	26.5	102.4	51.5	247.8	76.5	449.8
2.0	6.1	27.0	104.8	52	251.2	77	454.5
2.5	7.6	27.5	107.2	52.5	254.7	77.5	461.2
3.0	9.2	28.0	109.7	53	258.2	78	464.0
3.5	10.8	28.5	112.2	53.5	261.7	78.5	468.8
4.0	12.5	29.0	114.7	54	265.2	79	473.5
4.5	14.1	29.5	117.2	54.5	268.8	79.5	478.3
5.0	15.8	30.0	119.7	55	272.4	80	483.2
5.5	17.4	30.5	122.2	55.5	276.0	80.5	488.1
6.0	19.1	31.0	124.8	56	279.6	81	493.0
6.5	20.8	31.5	127.0	56.5	283.3	81.5	498.0
7.0	22.5	32.0	130.0	57	287.0	82	502.9
7.5	24.2	32.5	132.6	57.5	290.7	82.5	507.9
8.0	26.0	33.0	135.3	58	294.4	83	512.8
8.5	27.7	33.5	137.9	58.5	298.2	83.5	517.9
9.0	29.5	34.0	140.6	59	302.0	84	523.0
9.5	31.3	34.5	143.3	59.5	305.8	84.5	528.1
10.0	33.1	35.0	146.0	60	309.6	85	533.2
10.5	34.9	35.5	148.7	60.5	313.5	85.5	538.3
11.0	36.8	36.0	151.5	61	317.3	86	543.5
11.5	38.6	36.5	154.3	61.5	321.2	86.5	548.7
12.0	40.5	37.0	157.1	62	325.2	87	553.9
12.5	42.4	37.5	159.9	62.5	329.1	87.5	559.2
13.0	44.3	38.0	162.8	63	333.1	88	564.5
13.5	46.1	38.5	165.7	63.5	337.1	88.5	569.8
14.0	48.2	39.0	168.6	64	341.1	89	575.1
14.5	50.0	39.5	171.5	64.5	345.1	89.5	580.5
15.0	52.1	40.0	174.4	65	349.2	90	585.9
15.5	54.1	40.5	177.3	65.5	353.3	90.5	591.3
16.0	56.1	41.0	180.3	66	357.4	91	596.8
16.5	58.1	41.5	183.3	66.5	361.6	91.5	602.3
17.0	60.2	42.0	186.3	67	365.7	92	607.8
17.5	62.2	42.5	189.3	67.5	369.9	92.5	613.3
18.0	64.3	43.0	192.4	68	374.2	93	618.9
18.5	66.4	43.5	195.5	68.5	378.5	93.5	624.5
19.0	68.5	44.0	198.6	69	382.7	94	630.1
19.5	70.6	44.5	201.7	69.5	387.0	94.5	635.8
20.0	72.8	45.0	204.9	70	391.3	95	641.5
20.5	75.0	45.5	208.0	70.5	395.6	95.5	647.2
21.0	77.2	46.0	211.2	71	400.0	96	653.0
21.5	79.4	46.5	214.4	71.5	404.4	96.5	658.8
22.0	81.6	47.0	217.7	72	408.8	97	664.5
22.5	83.8	47.5	220.9	72.5	413.3	97.5	670.3
23.0	86.1	48.0	224.2	73	417.8	98	676.2
23.5	88.4	48.5	227.3	73.5	422.3	98.5	682.1
24.0	90.7	49.0	230.8	74	426.8	99	688.1
24.5	93.0	49.5	234.1	74.5	431.3	99.5	694.1
25.0	95.3	50.0	237.5	75	435.9	100	700.0

mm. to 15 mm. can be used satisfactorily. The results will vary somewhat with the size of the tube because of the variation in the ratio of volume of solvent to volume of rubber.

Racks for Immersion Tubes:

The tubes can be placed in racks either vertically or at an angle to the horizontal just large enough to keep the liquid from flowing out if the cork comes out. In this way a large number of tubes can be placed in a small constant temperature oven or thermostat.

Reading Table:

The reading table (Fig. 1) about a foot square and having a glass top is set at an angle of about 15 deg. with the horizontal. Standard millimeter graph paper, marked in ink at convenient lines to facilitate reading the increase in length of the test specimen, is fastened over the glass by means of thumb tacks or tape. A mirror is placed under the glass at a 45-deg. angle and the light from an ordinary light bulb at the side is reflected upward through the paper. This arrangement prevents heating and consequent shrinkage of the paper.

Operation:

The small piece of rod is first put into the tube and then the test specimen. The original length of the sample is then checked and any deviation from the standard length is applied as a correction to ΔL. For example, if the sample length is 100.5 mm. the correction to ΔL is -0.5 mm. Next 10 ml. of liquid are added and the tube either corked or sealed. The tube is then kept at the specified temperature for the specified time and then allowed to come to room temperature. The difference in length from 100.0 mm. is read to the nearest 0.5 mm. The correction to ΔL is added to give ΔL corrected, in millimeters. Since the original length is 100 mm., ΔL in mm. is also ΔL in per cent. The corresponding ΔV in per cent is then read directly from Table I. If more than one time of immersion is requested, the operation is repeated.

Parallax in reading the length is eliminated when the line being read goes straight across the tube as seen through the liquid. If the inked lines are drawn as shown in Fig. 1, two black dots will be seen in the wall of the tube and these should be on the corresponding line under the tube.

In some cases the test specimen curls slightly which may make a difference of as much as 0.5 mm. in ΔL. A piece of small, stiff wire bent zigzag in a plane can be used to hold the sample flat if the tube is corked.

Typical results and the method of recording are given in Table II.

Discussion of Test Results

Compounds Used:

Compounds RG and RT, pure gum rubber and rubber tread, respectively, were tensile sheets cured in a press by the standard A.S.T.M. procedure. Compound RCG was a high-gum, air-curing compound which was calendered cold to get maximum calender grain and cured by standing at room temperature. Compounds N and P, neoprene and perbunan, respectively, were mixed and calendered in the factory and cured in a press.

Effect of Solvent Volume on ΔV:

In Table III are given data obtained with three different sized tubes together with results secured with the standard A.S.T.M. procedure. In the 8-mm. tubes were 4.3 ml. of solvent; in the 10-mm. tubes, 10 ml.; and in the

TABLE II.—IMMERSION IN GASOLINE.

7 days at room temperature.

Compound	ΔL, mm.	Correction to ΔL	ΔL Corrected, mm.	ΔV, per cent
RT	38.0	0	38.0	162.8
	38.0	0	38.0	162.8
P	2.5	−0.5	2.0	6.1
	1.5	0	1.5	4.5

TABLE III.—SOLVENT VOLUME *versus* VOLUME INCREASE.

Tube Size, mm.	Ratio, Vol. Solvent to Vol. Rubber	Volume Increase, per cent					
		Alcohol 7 days	Hexane 7 days	Acetone 7 days	Benzene 7 days	Lubricating Oil 7 days	Lubricating Oil 14 days
Compound RT							
8	11.6	3.4	142.0	...	...	251.2	333.2
10	27.0	5.0	148.7	...	...	341.3	493.1
15	67.5	3.0	146.0	...	...	436.1	498.5
A.S.T.M.	40.5	4.8	151.7	...	...	300.5	[a]
Compound N							
8	11.6	...	...	27.3	...	52.1	60.2
10	27.0	...	...	26.0	...	60.2	96.6
15	67.5	...	...	23.4	...	65.4	71.8
A.S.T.M.	40.5	...	...	26.9	...	58.2	76.2
Compound P							
8	11.6	...	...	...	130.5	...	7.6
10	27.0	...	...	...	121.5	...	7.6
15	67.5	...	...	...	129.1	...	9.2
A.S.T.M.	40.5	...	...	...	152.8	...	9.3

[a] Disintegrated.

TABLE IV.—CALENDER GRAIN *versus* VOLUME INCREASE.
7 days at room temperature.

Solvent	Volume Increase, per cent			
	Across Grain	With Grain	Average	A.S.T.M.
Compound RCG				
Acetone	19.1	16.4	17.8	15.6
Hexane	249.5	137.9	193.7	203.2
Benzene	365.7	200.1	282.8	302.2
Compound RT				
Alcohol	1.5	3.0	2.25	4.77
Hexane	142.0	142.0	142.0	151.7
Benzene	225.0	220.9	223.0	241.0
Compound N				
Acetone	29.5	25.1	27.3	26.9
Hexane	20.0	15.8	18.4	17.5
Benzene	211.2	165.7	188.5	200.5

15-mm. tubes, 25 ml. The immersions in lubricating oil were at 80 C., the others at room temperature. These results are the average of two determinations, one with the grain and one across the grain. The A.S.T.M. results are also the average of two determinations.

These results indicate that usually the volume of solvent does not have any pronounced effect but that in some cases, notably with compound RT in lubricating oil at 80 C., it has considerable effect.

Effect of Calender Grain:

In Table IV are given the averages, for three compounds, of two determinations with the grain, two across the grain, and two by the A.S.T.M. method. These immersions were run in 8-mm. tubes at room temperature. From these results it is apparent that the calender grain has a very pronounced effect on ΔL. Part of the deviation between the new method and the A.S.T.M. method is probably due to the fact that the thickness does not change in proportion to the length. The results also indicate that there is considerable calender grain left in this sheet of compound N and very little in that of compound RT.

Since the relation between ΔL and ΔV in the new method is based on the assumption that swelling is isotropic, it is obvious that if the calender grain is kept at a minimum, the most satisfactory comparative results will be secured.

Because the method is sensitive to calender grain it offers an easy means of determining the extent of this grain by determining ΔL in two directions. Comparison of the ΔL in two directions on a tensile sheet with the ΔL of a strip cut from a piece of extruded tube of the same stock should give a measure of the grain left in the tube.

TABLE V.—VOLUME INCREASE *versus* THICKNESS OF SAMPLE.
4 days at room temperature.

Thickness, in.	Volume Increase, per cent					
	Gasoline		Benzene		Alcohol	
	Tube	A.S.T.M.	Tube	A.S.T.M.	Tube	A.S.T.M.
Compound RT						
0.017	193.7	164.9	277.0	277.2	2.4	5.6
0.068	199.5	211.3	283.7	316.6	2.7	4.3
0.114	190.8	211.8	226.7	300.3	2.3	3.9
Compound RG						
0.026	315.4	263.7	478.5	431.6	1.8	4.2
0.062	304.7	300.4	434.1	438.9	5.1	5.7
0.107	302.3	301.6	413.3	435.6	5.1	6.1

Effect of Thickness of the Sample:

In Table V are given data on two of the stocks sheeted and cured to different thicknesses. All of the immersions were run at room temperature in 8-mm. tubes. Some difficulty was experienced in working with the thinnest sheets by both methods. In general the differences are not great and are probably due in part to differences in the ratio of solvent volume to rubber volume.

Comparison of the New Method with A.S.T.M. Method

Comparison of Results:

In Table VI are given data comparing the results obtained by the new method with those obtained by the A.S.T.M. method. All results reported are the average of two determinations. In the new method the strips were cut at right angles to each other and the immersions were run in 10-mm. tubes. Other comparative data have been given in the preceding tables.

In many cases the results are very close. In others the numerical check is not good although it is close enough for practical purposes. For example, in a preliminary comparison of compounds for various uses the difference between a ΔV of 3.0 and one of 6.0 or between 218.0 and 241.0 would be of minor importance even though, as numerical checks, such results would not be considered good.

TABLE VI.—COMPARISON OF METHODS.

Time of Immersion, days	Volume Increase, per cent							
	In Hexane, Room Temperature		In Benzene, Room Temperature		In Acetone, Room Temperature		In Lubricating Oil, 80 C.	
	Tube	A.S.T.M.	Tube	A.S.T.M.	Tube	A.S.T.M.	Tube	A.S.T.M.
Compound RT								
1	147.3	139.2	211.2	221.1	...	...	...	...
2	147.3	146.2	216.0	235.2	...	...	...	...
4	148.7	148.8	216.0	238.3	...	...	...	...
7	148.7	151.7	217.7	241.0	...	...	...	...
Compound RG								
1	...	...	...	...	21.6	20.9	256.4	223.5
2	...	...	...	...	22.5	20.4	288.8	251.9
4	...	...	...	...	18.3	20.4	351.2	288.8
7	...	...	...	...	18.3	20.5	446.0	368.2
14	...	...	...	...	...	...	[a]	[a]
Compound P								
1	3.0	6.0	...	...	...	...	6.1	3.7
2	3.0	2.6	...	...	...	...	8.5	4.2
4	2.3	2.0	...	...	...	...	7.7	5.7
7	2.3	2.0	...	...	...	...	6.1	7.9
14	...	...	...	...	...	...	7.6	9.3

[a] Disintegrated.

TABLE VII.—VOLUME INCREASE IN FREON 12.

Compound	Volume Increase, per cent	
	Room Temperature, 26 days	250 F., 2 days
RT	36.8	36.8
N	6.1	4.5
P	−1.5	−3.0

Accuracy:

There is a question as to which method gives the more accurate results. The greater precision of the gravimetric method is counterbalanced by the sources of error inherent in the manipulations.

Reproducibility:

To determine the reproducibility of results, a large number of individual results were examined to see how closely they agreed for supposedly identical determinations. Since ΔL is read only to the nearest 0.5 mm. there are many cases where the spread in ΔL is 0.5 mm. For a swelling of less than 50 per cent this ΔL value corresponds to about 1.5 to 2.0 per cent in ΔV whereas for a swelling of 150 per cent it corresponds to 3.0 per cent and for a swelling of 400 per cent, to 4.4 per cent. Of 288 determinations there were 14 cases where the spread between the two values of ΔL was more than 0.5 mm. This was true in only one case where the swelling was less than 50 per cent. Of 156 determinations by the A.S.T.M. method there was only one case where the spread was more than 2.5 per cent and the swelling less than 50 per cent. With low swelling the checks are closer by the A.S.T.M. method. With swellings of over 50 per cent, however, there were 41 cases where the spread was over 2.5 per cent and of these it was over 5 per cent in 24 cases and over 10 per cent in 7. With higher swellings the two methods seem about equal in reproducibility.

Speed of Operation:

The time required for the measurements by the new method is 10 to 20 per cent of that required by the present A.S.T.M. method. The calculations, which take as much time as the measurements by the A.S.T.M. method, are entirely eliminated. The time of the operator required for a single result is thus only 5 to 10 per cent of that required by the A.S.T.M. method.

Difficult Tests:

Some types of immersion which are very difficult by the A.S.T.M. method are easy by the new method, for example immersion in Freon at high temperatures. In Table VII are given results of such immersions obtained by the new method. The tubes with samples in them were cooled in dry ice and the Freon 12 distilled in from a cylinder. The tubes were then sealed in a blast lamp. They were kept at room temperature for 26 days and then at 250 F. for 2 days.

Modifications of the New Procedure:

With properly prepared tensile sheets, a single strip can be cut by an experienced operator and immersed without checking on the initial length. Such a procedure is very fast and gives fairly accurate results.

The use of two strips cut at right angles to each other and the checking of the initial length give improved accuracy and require little time.

Various possible improvements for both speed and accuracy are rather obvious. An improved method of cutting samples would eliminate the need for the initial reading. The use of tubes with flat bottoms of uniform thickness together with a suitable holder would eliminate the necessity of aligning the bottom end of the strip. A suitably mounted, movable, low-power microscope would make the readings of ΔL more accurate. A scale made for the direct reading of ΔV would eliminate the need for using the conversion table. All of these improvements could be incorporated into special apparatus at relatively low cost so that accurate determination could be made very rapidly.

Conclusion

The immersion procedure described here is much faster than the present A.S.T.M. method and gives results of comparable accuracy. It requires less space and less solvent. The most serious objection to it is the occurrence of anisotropic swelling due to grain in the rubber. However, there is usually more grain in manufactured articles, such as hose, than in tensile sheets. Both methods are useful chiefly for the preliminary evaluation of compounds. The final test frequently is made on the finished article under special conditions.

The sensitivity of this test to grain effects suggests that its use with a good swelling agent will be a useful tool for measuring the extent of such grain in various compounds.

Acknowledgment:

The author wishes to express his appreciation to B. M. G. Zwicker who made most of the experiments for this study.

British Bibliography on Spectroscopy

Recently received from the British Non-Ferrous Metals Research Association, Euston St., London, N. W. 1, is a publication entitled "Bibliography of Spectrochemical Analysis" by D. M. Smith.

This book lists some 500 references with explanatory notes on most of them and in a number of cases short abstracts. The publication would undoubtedly be of interest to spectroscopists particularly in the field of metallurgy, since it is limited primarily to this field and to literature on subjects closely related thereto.

Copies of this publication can be obtained from the British Non-Ferrous Metals Research Association at three *s.*, postage included.

Address Wanted

Anyone knowing the present address of the following member, whose last-known address is given below, is asked to notify the Secretary-Treasurer:

Robert William Kinnear, 1540 N. Meridian St., Indianapolis, Ind.

Some Factors Affecting Flow-Table Determination of Mortar Consistency

By F. O. Anderegg[1]

RESULTS REPORTED to Committee C-12 on Masonry Mortars by cooperating laboratories on the cube strengths of mortars made from local sands and masonry cements or mixtures of portland cement and lime varied so greatly that the author has been interested in determining the causes. The cooperating laboratories had been directed to bring the mortars to certain consistencies as determined by the 10-in., 1/2-in. drop flow table described in the A.S.T.M. Tentative Specifications for Masonry Cement (C 91 – 38 T),[2] but the variable nature of the supports was brought out in the discussion. The question of the accuracy of the various flow tables in meeting the specifications also came under scrutiny, so that correspondence with makers of the instrument was carried out by the author. This elicited the information that in some machines the impact was on the cam and in some on the shoulder. In the former case, the drop varied, with the speed of rotation, from 0.4 in. upward.

PREPARATION OF TEST MORTARS

A mortar that will not change appreciably with time must be used in experimenting with the various factors capable of affecting the results of the flow table. Mortars made from soaked lime putties and sand, when given sufficient stirring to overcome the effects of the thixotropic character of the lime, and when loss of moisture is prevented, are suitable for this purpose.

Putties were prepared by soaking a fine-grained Ohio dolomitic finishing lime *B*, by soaking a completely hydrated Pennsylvania dolomitic lime *D*, and by hydrating a pulverized, high-calcium, Pennsylvania quicklime *F* with a large excess of water.

The sand used was from a local river, partly of glacial origin and partly from local outcroppings of sandstone. It contained 0.3 per cent of clay and was given sufficient soaking to saturate the clay thoroughly. This required an amount of water equal to 1 per cent of the dry weight of the sand, including the absorption of the sand grains themselves. The mortars were made up with 225 parts of sand to 40 parts of lime solids by weight. Since numerous experiments have failed to show any significant difference between the flow over a table wiped quite dry and over one lubricated with oil, most of the experiments reported here have been run with a dry surface. The spindle was kept well lubricated to maintain a constant minimum friction. It is believed the table should rotate slowly during operation, to insure uniform flow toward the periphery.

EFFECT OF IMPACT

The force imparted to the mortar by the impact of the flow table may be governed by the weight of the flow table, by the distance of the fall, by the part of the apparatus receiving the impact, and by possible cushioning action of the support. To study these effects, a flow table was fabricated having an extra long shaft so that the impact would be on the cam. The weight of the table was 13.00 lb. at the start, and the distance fallen was measured as 0.400 in. when rotating the cam at 100 rpm. This gave an impact energy of 5.20 in-lb. With this setup flows were run with the three different lime mortars, each at three consistencies; and with the flow table on a variety of supports, ranging from a wooden table that was fairly stiff, to a heavy concrete pier to which the table could be tightly bolted. This pier is 3 ft. high, with a base 12 by 12 in. and a top 8 by 12 in. and weighs approximately 370 lb. The table was also set loosely on the pier with the nuts removed, permitting a small amount of bouncing. It was also placed loose on the concrete floor and on a small brick pier, 8 by 8 by 22 in.

After completion of these experiments, the shaft was shortened and the cam was undercut so that the impact would be on the shoulder, with a drop of 0.500 in. The same measurements were made as before. The table was then put in a lathe and turned down until the weight was 9.00 lb., and the flows were again measured.

Each time before the mold was filled, the mortar was very thoroughly stirred up, and in filling the mold care was taken to avoid compacting, for the reasons described below. The flows observed with the three different lines seldom differed more than 0.25 per cent, corresponding to 0.1-in. diameter difference, and the averages of the three measurements are given in Table I.

Of the variables studied in these experiments, the nature of the support has had the greatest effect on the results. It is obvious that the flow table should be bolted to concrete piers of adequate inertia. The effect of the force transmitted to the mortar from the impact, the energy of which ranged from 5.00 to 6.48 in-lb., appeared to be little greater than the error of the measurement. The results when the impact was on the cam seemed to indicate a possible cushioning action of a small magnitude.

EFFECT OF THE AGE OF THE MIX

When portland cement is mixed with water it combines chemically with part of the water. The stiffening and use of water are progressive, so that an ever-increasing addition of mixing water is required to maintain a given working consistency. Hydrated lime absorbs water rapidly at first and then at a slower rate, so that smaller changes in consistency occur after the first hour at room temperature. A dry hydrated lime mix stiffens much

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, Pa.

[1] Consulting Specialist on Building Materials, Newark, Ohio.

[2] 1939 Book of A.S.T.M. Standards, Part II, p. 877.

TABLE I.—THE EFFECT OF THE IMPACT AND FLOW TABLE SUPPORT ON THE SPREAD OF 1:3 LIME MORTARS.

Energy of Impact	Consistency	Percentage Flow				
		Flow Table Bolted to Concrete Pier	Flow Table Loose on Concrete Pier	Flow Table Loose on Floor	Flow Table Loose on Brick Pier	Flow Table Loose on Wooden Table
0.400 × 13.00 = 5.20 in-lb., on cam	Stiff	70	67	68	65	60
	Medium	110	107	106	103	98
	Wet	135	130	133	127	123
0.500 × 12.96 = 6.48 in-lb., on shoulder	Stiff	72	69	71	68	64
	Medium	112	108	107	105	100
	Wet	138	132	133	130	126
0.500 × 9.00 = 4.500 in-lb., on shoulder	Stiff	69	67	68	65	62
	Medium	109	105	107	103	97
	Wet	133	128	131	125	120

less than a mix with portland cement. Clays vary greatly in character and in the increasing stiffening on standing. Mixtures of portland cement and lime, and masonry cements, are intermediate between portland cements and dry hydrated lime.

The phenomenon of dilatancy or packing of the sand also contributes to the apparent stiffening. It is interesting to note that when the mason proposes to "spot" mortar on the end of a brick or tile, he gives the trowelful of mortar two or three moderate shakes to promote dilatancy, which means better mortar coherence.

The effect of time on consistency was determined with a number of mortars of different composition, ranging from straight lime putty mortar, 1:3 by volume, to straight 1:3 portland-cement mortar. The procedure followed was to mix mechanically in a "pony" mixer with the addition of enough water to bring the consistency to 135 per cent flow at 15 min. after starting the mixing. The mortar was then allowed to stand well covered to prevent loss of water. Flows were determined at the end of 1 hr. after mixing started and at hourly intervals up to 6 hr., with the usual thorough mixing before placing in the mold. Typical results are given in Fig. 1.

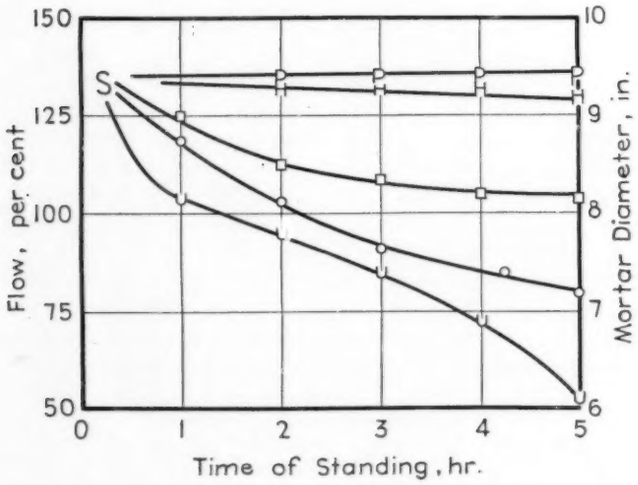

Fig. 1.—The Effect of Age on the Consistency of Mortars.

	Water, per cent
S = Starting point, 135 per cent flow at 16 min.	....
P = Mix 0:1:3 with putty B	....
H = Mix 0:1:3 with dry hydrate B	32.5
□ = Mix 1:2:9 with putty B	31.0
O = Mix 1:2:9 with dry hydrate B	23.1
U = Mix 1:0:3 with portland cement	21.9

The drop in the flows of mortars containing portland cement is very marked. This fact points strongly to the need of very exact specification of time intervals in testing masonry cements and mortars. Since but a small part of masonry mortars is used in less than an hour after mixing and since the curves reproduced in Fig. 1 have some tendency to flatten off after 1 hr., it is suggested that mortars should be mixed, say, for 10 min. with enough water to bring them to a flow of something like 130 per cent. Then they should be allowed to stand for an additional

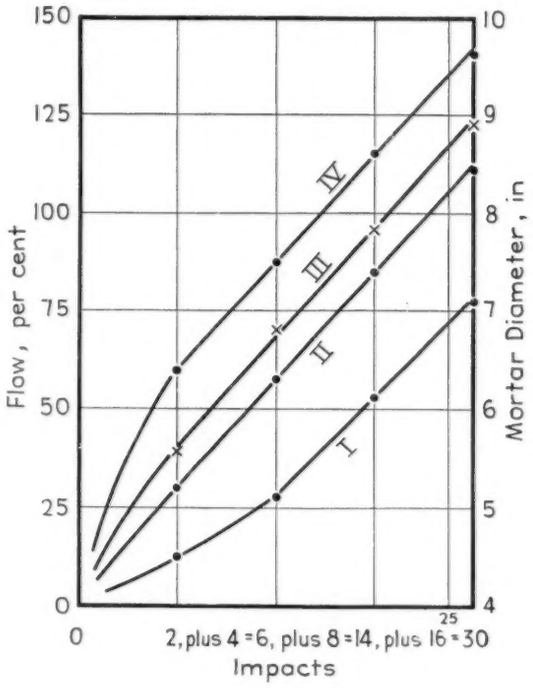

Fig. 2.—The Progress of Flow with the Number of Impacts.

Curves I, II, IV three consistencies, standard mold.
Curve III medium consistency, tall mold.

50 min. and the flow adjusted to, say, 105 per cent. With a little experience it is not difficult to adjust the water content at the start by the appearance in the mixer to produce the desired flow after 1 hr. After this, the fabricating of specimens should be accomplished with the addition of no more water and within a limited time. When beams are to be fabricated, this time should not exceed, say, 10 min.

The constant flow observed with well-soaked lime putty mortars is the reason for their choice in studying characteristics of the flow table and its support, as described above.

Effect of Manipulation of the Mortar

While variations of the order of 10 to 12 per cent have been obtained with different supports for the flow table, even greater differences may result from manipulation of the mortar by the operator. For instance, with a 1:3 portland cement mortar after standing for 1 hr., the apparent flow was only 60 per cent when the mold was filled with a minimum amount of handling, but on thorough mixing the flow reached 85 per cent. In filling the mold, it is recommended to secure complete filling by

placing the mortar with the point of the trowel, while that tool is held nearly vertically, to avoid compacting. If the flow is practically uniform in all directions, a uniform filling of the mold is indicated, provided the mold has been removed by lifting directly upward. The effects of mixing and placing are obviously much more serious with stiff than with more fluid consistencies.

Some Flow Characteristics of Mortars

On observing the behavior of different mortars as they spread out over the flow table, certain differences between the rates of flow during the first few impacts and later ones were noted. A systematic study has been made with a large number of mortars covering the range from straight portland cement to straight lime. Variations were also made in the ratio of sand to cementitious material and in the flows. Curves typical of a great variety of mortars that are suitable for masons to use are reproduced in Fig. 2.

After trying various ways of plotting the results, a method of noting the rate of spread of mortar was worked out yielding results which give curves that can be readily interpreted. After reading the initial diameter, two impacts were given and the diameter of the mortar was again measured. It was also measured after 6, 14, 30, and, occasionally, 62 and 126 impacts.

Measurement of the flow was facilitated by a series of concentric rings marked on the table, the distance from the rings to the mortar being measured to 0.02 in. with a small rule at four points. Duplicate runs could usually be made checking diameters within 0.1 in.

Since the mortar spreads out over an area, while only the diameter is measured, it seemed logical to plot the impacts in a geometrical progression. Doing so has led to the observation that most well-mixed mortars, placed without appreciable compacting, flow out quite uniformly after the first six impacts, on the flow table used in these experiments. Mortars of a wide range of composition and consistency have exhibited identical flow characteristics between six and 30 bumps.

Variations from this rule have been noted with the stiffest consistencies because of the difficulty in getting them properly stirred up and in placing them in the mold without compacting. The result is sometimes a curve concave upwards as the more fluid constituents tend to bleed out, or with mortars containing highly plastic lime. The effect of accelerating flow seems at times to be aided, as the mortar approaches the edge of the table, by some vibration that takes place at the edge. This was checked by placing a glass marble in various positions on the table and observing the bounce heights. These were appreciably higher when the marble was placed near the edge of the flow table than in the center. The progression of the compression wave following the impact seems to emulate a cracking whip. Variation in this vibration among tables of different manufacture may cause differences in results.

These observations suggest that straight line flow might be used as a criterion of adequate mixing. Laboratories handling mortars of about 70 per cent flow are requested to measure the spreading by increments. If the last increment is greater than the one between 6 and 14 impacts, the mortar should be given a thorough remixing with the wrist loose and the stepwise flow again observed. Please communicate to the author any results obtained. Also note the height of bounce of a glass marble at the center and at the edge of the flow table.

The slopes of the curves in Fig. 2 suggest that any number of impacts above, say, six would be sufficient to bring out small differences in consistency. But there does not seem to be any very serious objection to the present specification calling for 25 impacts. The constancy of these slopes, repeatedly confirmed, indicates that, so far as *spreading* goes, the mason can satisfactorily use any of these mortars, provided they have been freshly remixed on the board. This does not mean, of course, that after they are spread, all mortars will behave properly on absorbent units.

Effect of Shape and Size of Mold

Since the differences among these consistencies are brought out in the first six impacts, it seemed of interest to accentuate the spread by using higher molds. The standard mold was doubled in height to give a top diameter of 1.5 in., but the small opening at the top greatly increased the difficulty of filling the mold. A somewhat higher flow was obtained in the first two bumps, but the increase thereafter was normal, as shown in curve III of Fig. 2. A smaller mold, designed by Cowper,[3] was also used. It is still more difficult to fill and seemed to possess no particular advantage for mortars over the other two. No change from the present standard mold seems warranted by the experience reported here.

However, advantage could be taken of these observations in designing a mold to give greater differentiation between flows. The upper diameter of the mold should be kept the same as at present, as well as the slope of the sides. The height might be adjusted so that the most fluid mortar to be used would not overflow in six impacts.

Other Types of Apparatus

Some objections have been raised to the flow table as being perhaps too complicated and costly. A simpler apparatus might be devised which would give an adequate measure of consistency. A flow trough has been used with concrete,[4] suggesting trial of a small replica for mortars. Therefore a trough 3 in. in diameter and 12 in. in length was constructed. The movable partition extended from a line 4 in. from the closed end at the top to 5.5 in. at the bottom. The trough was wiped dry each time before use. The trough showed greater sensitivity with flows of less than 100 per cent, as determined on the flow table. But this advantage was more than neutralized by the fact that the trough showed only small differences in mortars having flows between 100 and 135 per cent as measured on the flow table. This confirms previous experience with the concrete trough.[5] A few experiments were performed with the Braebender apparatus.[6] It also failed to show much sensitivity among the more fluid consistencies.

Portions of the three lime mortars used in studying the effect of the impact were sent to P. L. Rogers, whose co-

[3] A. D. Cowper, "Building Limes II, Flow Table and Workability," *Journal*, Soc. Chemical Industry, Vol. 56, p. 456T (1937).

[4] Donald M. Burmister, "The Concrete Flow Trough," *Proceedings*, Am. Soc Testing Mats., Vol. 31, Part II, p. 554 (1931).

[5] F. O. Anderegg, Discussion of Burmister paper, *Ibid.*, p 570.

[6] E. O. Rhodes, "A Machine for Testing Highway Subgrade Soils," *Proceedings*, Am. Soc. Testing Mats., Vol. 38, Part II, p. 551 (1938).

operation is gratefully acknowledged. He ran these as received and at other consistencies on the A.S.T.M. standard flow table.[2] The Cowper table,[3] which was devised to give more vibration, was also used. The flows of the mortars as received by Rogers varied 0, +3, and —1 per cent from the flows measured when the mortars left Newark, Ohio. The shapes of his flow curves, plotted as in Fig. 2, were practically identical therewith. Lime *B* in the low consistency produced a slight upward concavity, as noted above for very plastic lime. This similarity held also for all three lime mortars on the Cowper table when the standard A.S.T.M. mold was used, and also with the smaller mold, 1 1/2 in. in diameter at the top, 2 5/8 in. at the bottom, and 3 in. high, for two of the mortars. The mortar *F*, however, with a high yield lime, had a steeper curve with vibration. Cowper has used this vibrating table on lime putties and found those that flowed out most slowly had best workability under the plasterer's trowel. For mortars, a vibrating table seems to have no special advantage.

From the results obtained, it appears that to get consistent results with a flow table, the following points are important: (*1*) very thorough mixing of the mortar, (*2*) filling the mold without compacting, (*3*) a table bolted to a substantial concrete pier, and (*4*) impact on the shoulder of the table. The apparatus seems to measure consistency fairly well, but it fails to distinguish differences in the characteristics of limes. Certain elusive properties are also encountered that escape the water retention test. An adequate test for these properties is needed.

Federal Officials at President's Dinner

In connection with the A.S.T.M. Spring Meeting in Washington, the President of the Society, Dr. W. M. Barr, gave a dinner on Wednesday evening, March 5, to a selected group of officials in responsible charge of the development of specifications for and procurement of materials in various departments of the Government, and a representative group of officers of the Society and chairmen of certain of the Society's committees dealing with important defense materials. The purpose was to promote acquaintanceship between the two groups and to consider at first hand the most effective ways in which the facilities of the Society for the formulation of standard specifications and tests and the promotion of the knowledge of the properties of materials can be used in the National Defense Program.

The following representatives from various Government departments were present:

G. M. Barnes, Brig. General, U.S.A., Office of Chief of Ordnance, War Department

E. C. Forsyth, Lt. Commander, U.S.N., Bureau of Ships, Navy Department. Chairman, Metals Committee F.S.E.C.

W. M. B. Freeman, Chief, Contract and Purchase Branch, Procurement Division, Treasury Dept.

J. H. Frye, Major, U.S.A., Ordnance Department, War Department

Carl A. Hardigg, Colonel, U.S.A., Executive Officer, Supply Division, Officer of Quartermaster General, War Department

Ray M. Hare, Lt. Colonel, U.S.A., Chief of Standards Division, Planning Branch, War Department. Represented by Lt. John H. Fitch

E. H. Leavey, Lt. Colonel, U.S.A., Chief, Engineering Branch, Construction Division, Office of Quartermaster General, War Department. Represented by E. B. Black

Robert Le Fevre, Assistant Director of Procurement, Procurement Division, Treasury Department

D. G. Lingle, Major, U.S.A., Air Corps, War Department, Member Permanent Working Committee, Joint Aeronautical Board

Clifton E. Mack, Director of Procurement, Procurement Division, Treasury Department

Douglas C. Mac Keachie, Deputy Director of Purchases, Office of Production Management

A. S. McAllister, Assistant Director, National Bureau of Standards

H. V. McCabe, Commander, U.S.N., Ret., Liaison Officer with Standards Division, Planning Branch, War Department

Donald M. Nelson, Director of Purchases, Office of Production Management

W. S. Newton, Lt. Commander, U.S.N., Naval Gun Factory, Navy Department

A. M. Pride, Commander, U.S.N., Bureau of Aeronautics, Navy Department. Member Permanent Working Committee, Joint Aeronautical Board

Carl A. Trexel, Captain, U.S.N., Chief, Design Division, Bureau of Yards and Docks, Navy Department

Henry Williams, Rear Admiral, U.S.N., Assistant Chief, Construction and Repair, Bureau of Ships, Navy Department

William C. Young, Lt. Colonel, U.S.A., Assistant Director, Production Division, War Department

Mr. N. F. Harriman, Vice-Chairman, Federal Specifications Executive Committee, was prevented by illness from attending.

An interesting and entirely informal discussion followed the dinner concerning present emergency materials problems of the Government departments, the work of the Society, its relation to Government specification and procurement problems, and the directions in which the already extensive cooperative work between the Federal Government and A.S.T.M. in the development of specifications could most effectively be extended.

Army Specification Guide 1941

Many members of the Society who are concerned with National Defense efforts may wish to procure a copy of the Army Specification Guide 1941. This pamphlet is designed to establish a better understanding of the specifications used by the War Department which will result in more satisfactory service to the users of specifications. The bulletin gives purchase information only with respect to specifications and it is indicated that more complete information on Army purchasing can be found in another bulletin entitled "Army Purchase Information Bulletin." Copies of this bulletin can be obtained from the Purchase and Contract Branch, Office of The Assistant Secretary of War, Washington, D. C.

The 1941 Army Specification Guide can be obtained from the Standards Division, Planning Branch, Office of The Assistant Secretary of War, Washington, D. C. The guide contains information on specifications used by the War Department and on the numbering systems, refers to various types of specifications, gives data on how to apply for copies as well as detailed information on classes of U. S. Army and Federal specifications.

Symposium on Spectrographic Analysis

As pointed out in my introductory paper to the Symposium on Spectrographic Analysis, presented at the 1940 annual meeting,[1] the theme of the first session was accuracy requirements and reproducibility possibilities, a phrase, awkward enough it is true, yet it did bring out a series of very interesting if short papers and at times a spirited discussion. So, too, did the second session at which time emphasis was placed on the closely related subject, the presentation of results and their interpretation.

In other words, stress was laid on the practical features and uses which have brought spectrography into being and, because the art is new and the language has not developed so that clear concise definitions are the rule, there exists a need for clarification.

This represented an attempt to correlate the requirements of the metallurgical engineers who make up the bulk of the membership of the Society's committees dealing with non-ferrous metals with the ability of the spectrographer to meet them. To most of these engineers spectroscopy is new. Some expect too much, some too little. As a matter of fact many of the alloy specifications are new to the spectrographer. Each has something to learn from the other. Spectrography has its present (and future) limitations, as has engineering. Vagueness on the one hand and results based on wishful thinking or inadequate standards, methods, or experience do not help progress.

Much is being demanded of spectrography in speed and precision on the routine repetitive quantitative work where the method may only be on the way to standardizing. In fact, the spectrographer is expected to attain a skill and cover a field in a year or two which the analytical chemist has had years to attain. Refinements come only with the years. Again the spectroscopist has opened the field of Go-No-Go determinations which by the nature of analytical chemistry is, in the latter, much restricted and to many chemical analysts a closed book.

Yet Go-No-Go analyses are what the engineer wants once a specification has been set. Here there is a chance for misunderstanding between the supplier of the information desired and the user. Consider a specification calling for 0.007 per cent max. of lead. It is immaterial to the engineer whether the actual content is 0.001 or 0.005 per cent. It passes, and that is all he cares about. But if 0.006 or 0.008 is reported then he gets interested and wants to know the precision factor. In other words, a Go-No-Go method must often have a high degree of precision at the border line whether it be a "max." or "min."

The engineer, however, may not have a specification. He may be developing one and for a material unfamiliar to the spectrographer. Here there is need again for understanding each other's requirements and language. These and other allied questions were explored by accepted representatives of each group, some in formal or informal papers, some in discussion.

It has been thought wise to print the papers in view of the wide interest shown after the sessions closed and as a companion to those published in the January ASTM Bulletin in the "Symposium on Tools of Analytical Chemistry."

Thomas A. Wright
Chairman, Symposium Committee

[1] Thomas A. Wright, "Variables *Versus* Constants in Emission Spectrography," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1355 (1940).

The Spectroscope as a Production Tool

By H. H. Stout, Jr.[1]

The scope of Committee B-5 may be defined briefly as including copper and copper-base alloys, cast or wrought, for other than electrical use. It is the purpose of this paper to discuss the spectroscope principally in relation to committee activities pertaining to the drafting of specifications and the conformance of material thereto, rather than to attempt an extended technical description of the spectrographic method *per se*. That Committee B-5, collectively, is making use of the spectroscope is indicated by the fact that there are at least 16 installations in the laboratories of its various members. The replies to a circular letter on the subject, however, disclosed the fact that the opinions of the individual members are far from being unified and it is, therefore, not possible to set forth a single crystallized attitude of the committee as a whole.

The spread of opinion as expressed in the replies to the circular letter may be illustrated by the four following representative excerpts:

> 1. "Spectrographic methods can be applied to any of the alloys that come under the jurisdiction of B-5. The particular value of the spectrographic method lies in its ability to determine the limiting values of impurities rather than alloy compositions."

This opinion, with the easy familiarity of experience, indicates that the spectroscope has a proven ability accurately to perform many of the analyses required by the specifications and that advantage will accrue by its use. The opinion should carry considerable weight as it emanates from a man of very high technical standing, with a wealth of practical experience, under whose jurisdiction a

[1] Chief Metallurgist, Phelps Dodge Copper Products Corp., Elizabeth, N. J.; First Vice-Chairman, A.S.T.M. Committee B-5 on Copper and Copper Alloys, Cast and Wrought.

spectroscope has been successfully operated for a number of years.

2. ". . . . . I believe that the subject of spectroscopy should be carefully considered by Committee B-5."

This opinion exhibits an open-minded willingness to consider the possibilities of an unfamiliar subject and to dispassionately examine or determine advantages or disadvantages. It emanates from an administrator and characterizes the executive rather than the technical point of view.

3. "Incorporation of its use . . . . will result eventually in unnecessary and noncommercial restrictions being included."

4. ". . . . I am unalterably opposed to it."

In these two final opinions, we find the direct expression of a fear born possibly of experience that the official recognition of a new scientific instrument will impose arbitrary or unnecessary restrictions on a product; and that these restrictions will result in increased difficulty of manufacturing or testing, without compensating improvement in service performance. This potentiality merits mature reflection and should be constantly borne in mind by those who extend the use of this incredibly sensitive instrument into commercial channels.

Passing now to the position of the spectroscope in the not unexplored but almost unlimited realm of commercial, metallurgical analysis: admittedly the major problems of any laboratory are the accuracy of its chemical determinations, the cost thereof, and the time required. These determinations are in some cases markedly difficult or expensive and the results, on occasion, show poor reproducibility. Others not so difficult can be performed with the required degree of accuracy and speed by anyone of moderate intelligence and manual skill. Those charged with the administration of a chemical laboratory look to the spectroscope as a possible answer to the progressively more acute problem of minimization of error and reduction of cost. The questions are asked: "Can this device fulfill these functions and to what extent? Is it more foolproof than conventional methods and what are its limits of accuracy? How much developmental work is necessary before, on a given material, fast, cheap, dependable determinations can be made?" It is up to those skilled in the art to provide and publicize specific answers to these and many other generalized questions. Then, and only then, will the many nonusers begin to think in spectrographic channels and recommend the installation of this equipment.

Let us depart for a moment from the immediate scope of Committee B-5 and contemplate the extent of the analytical background of ordinary commercial brass. Our first thought is of a simple, routine, conformance analysis for copper, tin, lead, and iron. With the spectroscope in mind let us now reflect that two component metals have been separately mined, milled, smelted, and refined before alloying together and that in the direct line of metal process over 150 elemental determinations have been performed. It can reasonably be argued that these may not properly be considered as part of the analysis of brass. Nevertheless the determinations have been made, and cumulatively, by daily repetition over a long period of years, they have established the present high degree of metal purity. The picture can conceivably be still further enlarged to include analyses performed upon waste products, by-products, reverts, and fluxes which would increase the total by about 50 per cent to well over 200 determinations. Multiplied by all metals and all alloys, this constitutes the least explored and most promising field for developmental spectrographic effort.

In this enormous volume of repetitive production control analysis is represented a tremendous annual expenditure in dollars and man-hours. There is no question that potentially the spectroscope offers great promise for drastic reduction in cost and increase in speed together with maintenance or improvement of accuracy. Before this can be accomplished on a wide scale, the inertia of established analytical custom must be overcome. This responsibility, and it is a heavy one, rests squarely upon the shoulders of the chemists; the spectrographers are merely lighting the pathway. To establish itself, the spectroscope must be taken out of the research laboratory and placed in the control laboratory which, at the moment, is considerably more the exception than the rule.

Mr. Wright in his introductory paper[2] stated that "quantitative spectrography is an art built on the foundation of a science." Literally, as well as figuratively, art is the work of artists; and before the spectroscope can, without reservation, be considered as an economic tool for the mass production of analytical results, artisans must have replaced artists. Whether true or not, there is a general impression among many engineers not closely associated with this work that the spectroscope is still only a step beyond a scientific toy and that its applications are of a highly specilaized, low-volume nature consisting chiefly of research; in other words, that the spectroscope is yet, to an indeterminate degree, modern alchemy. This conception or impression must be dissipated.

It is, therefore, up to the spectrographers to so codify and simplify their art that a feeling of confidence will be engendered in the minds of the uninitiated. It is also up to the suppliers of spectrographic equipment, by publicity or otherwise, to emphasize this machine more as a standard tool and less as a specialized instrument for research. Most important—if its use is to be widespread—is that educational institutions include spectrography as a regular course, and encourage students to enter it as offering a promising field of employment and effort. Thus operators with basic training will become increasingly available to industry; and engineers will graduate with some working knowledge of the assets, liabilities, and limitations of this new and rapidly developing means for ascertaining chemical facts.

[2] Thomas A. Wright, "Variables *versus* Constants in Emission Spectrography," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1355 (1940).

The Use of Spectrographic Methods of Analysis by the Materials Engineer

By J. R. Townsend[1]

THE USE OF SPECTROGRAPHIC methods of analysis by the Materials Engineer may be considered as covering three principal applications:

1. The qualitative analysis of materials to determine the principal elements and impurities present.
2. The quantitative analysis of materials on a Go-no-Go basis for routine inspection.
3. The quantitative analysis of materials to determine the actual amounts of various elements present.

In the first group we find many cases where a qualitative determination is useful for the identification of the material or as the basis for future quantitative analysis where the spectrographic methods of analysis appear to offer more rapid results than more conventional methods of wet analysis. For example, the identification of materials is frequently possible if the presence or absence of one or two elements in amounts other than mere traces can be established. I have in mind the distinction between leaded and nonleaded brasses and bronzes which are frequently confused, the difference between chromium and nickel-chromium stainless steels and other similar materials which may become mixed in stock. In the case of defective parts, a qualitative spectrographic analysis may establish the presence or absence of deleterious impurities, thereby affording a ready clue to the cause of the failure of a given material. Such an analysis is particularly valuable because from it one can obtain an order of magnitude estimate. In many cases this is needed to reach an engineering decision.

In our materials work some of our specifications are based upon the control of certain elements within very small maximum amounts or within certain definite minimum and maximum limits rendering Go-no-Go methods of analysis of value. I have in mind the present specifications covering zinc-base die casting alloys as given in A.S.T.M. Specifications B 86 – 38 T.[2] In the case of alloy No. 23, lead, tin, cadmium, copper, and iron are controlled within very small limits. In the case of the first three, their presence in amounts greater than those specified affects the stability of the alloy. In such cases we frequently do not care to know the actual amount of these elements present but merely wish assurance that they are not present in amounts greater than those specified.

Again using the same example, the stability of the alloy requires the presence of magnesium within the limits of 0.03 to 0.08 per cent. In this particular case, Go-no-Go methods of analysis can be used and here the spectroscope should prove quite useful because the small amounts of magnesium involved make wet methods costly and slow.

The third field of application of spectrographic analysis may prove distinctly beneficial to the materials engineer in cases where a material must be rejected. For instance, in the case of alloy No. 23 previously cited, if we wish to reject a lot of material as being outside composition limits we must report the amount of the objectionable element present. In this case Go-no-Go methods are not satisfactory but quantitative results are required. If spectrographic methods of analysis will provide us with the quantitative answer it is frequently possible to save considerable time and money. More comprehensive sampling can be afforded also to provide a more justifiable basis of rejection. Otherwise, resort must be had to the slower, wet methods of analysis.

As an example of one way in which we have made use of spectrographic methods of analysis in the telephone field may be cited. It has been our custom not to approve the use of die-cast zinc-base parts until assurance has been given that the composition is within specification limits. This means that such parts are not die cast and then held in stock subject to approval by chemical analysis by wet methods. Under such a system parts had to be stored and, if defective, sent back and remelted with consequent loss of time in delivery of the finished product. With the use of spectrographic methods of analysis the control of deleterious ingredients can be imposed on the alloy pot and parts are only cast when the alloy is shown to be within specification limits. On this basis all finished parts otherwise sound can be used. There is no necessity for storage and no loss due to the remelting of off-composition parts.

[1] Materials Standards Engineer, Bell Telephone Laboratories, Inc., New York, N. Y.

[2] Tentative Specifications for Zinc-Base Alloy Die Castings (B 86 – 38 T), 1939 Book of A.S.T.M. Standards, Part I, p. 1153.

Qualitative Spectroscopy Before Standardization

By Henry Aughey[1]

IN DR. CLARKE'S excellent talk on microanalysis,[2] he said in essence that they used microanalysis to find out what is wrong, what is causing it, and what to do about it. I am going to use the same argument for spectroscopy as it is applied to many problems of the du Pont Co. We use it for trouble-shooting and to get quick answers. Our problem is not that of mass production of spectroscopic data as is the case, for example, in some of the metallurgical industries. We have instead of routine a variety of materials to investigate as quickly and inexpensively as possible in order to find out what is wrong or what is right about them.

[1] Chemical Dept., Experimental Station, E. I. du Pont de Nemours and Co., Wilmington, Del.

[2] Beverly L. Clarke, "Some Newer Trends in Analytical Chemistry," Symposium on Tools of Analytical Chemistry, abstract of paper published in ASTM BULLETIN, No. 108, January, 1941, p. 21.

Before specifications can be drawn up for standards it is obviously necessary to determine the tolerable concentrations of objectionable elements, but a still earlier task is to identify those impurities that can be associated with manufacturing difficulties or with the failure of a product in use. It is to this sort of problem that we have applied spectroscopy most frequently in our laboratory.

When something goes wrong for no obvious cause, spectrographic examinations of the product, of the raw materials, of portions of the equipment and, of satisfactory samples from previous runs often spot some outstanding element which can be correlated with the difficulty. Practical knowledge of the operations and tests may help to determine the significance of the results reported. The spectrograph, in addition to speed, has the advantage that the presence of a considerable number of elements in addition to the one responsible for trouble does not confuse the results; and, whether the disturbing element is present at concentrations of a few per cent or a few parts per million, it can still be picked up in many cases. This large range of sensitivity, coupled with the speed of such analyses, makes such a test more readily applicable than many of the conventional chemical techniques. By using concentration procedures such as precipitation, extraction, ashing, etc., the sensitivity can be increased considerably.

Difficulties are sometimes results of plain mistakes which could only be avoided by a fully impracticable thoroughness in sampling; for example, one package out of a large number may have some accidental contamination. An instance of this sort came to our attention some time ago when, in a pilot plant run, a material of unexpectedly low quality was obtained. The material was found by spectroscopic analysis to contain large amounts of manganese which was known to be deleterious but whose presence could not be explained. Tests of parts of the equipment, of the reagents and raw materials showed substantial freedom from manganese. It was found ultimately that a weld inside the equipment used was in an advanced state of corrosion and that the weld was made with a high-manganese alloy. This was an error on someone's part since no such material had ever been purchased knowingly. The spectroscopic analyses indicated the cause of the trouble although the conclusion that the contamination resulted from the equipment was considered impossible until the autoclave was torn down and the weld exposed to view. Such a use of the spectrograph is even more informative in research work than in plant control. Raw materials of different manufacture can be examined for purity and the results correlated with their behavior. Experiments, results of which appear to be haywire, can sometimes be explained by the presence of a previously unsuspected impurity which may catalyze certain reactions or the mistaken identity of a sample may be corrected. Such spectrographic examinations as these are made as nearly identical as possible, carefully keeping constant all the conditions of sample preparation, exposure, conditions of excitation, etc. The results are therefore more than purely qualitative. They are semiquantitative.

In our laboratory the spectrograph is sometimes used to permit the development of a rapid chemical analysis to a range of sensitivity not previously attainable. The spectrograph confirms the presence of an element, and chemical procedures are refined until adequate sensitivity is obtained. Likewise, where results of spectrographic analysis are questionable, chemical confirmation is made, if possible. After an analysis is established, the effect of impurities is often checked by deliberate addition of contaminants to reproduce the phenomenon in question.

Isolated instances of chemical contamination will occur in spite of all precautions, and the cause of trouble be difficult to trace, although it can be identified. The spectrograph, we have found, proves a rapid, sensitive, inclusive method of analysis for such instances.

Presentation of Spectroanalytical Results and Their Interpretation

By W. R. Koch[1]

Communication of spectroanalytical results must be understandable, convenient, significant, and precise. Standardization of nomenclature and form of report would insure understandability. Convenience, significance, and precision depend upon the method and purpose of the analysis.

In most producer laboratories quantitative spectroanalytical development work is concentrated upon a limited number of determinations in a few matrices. Standardization of form of specimen and other advantages of such specialization result in high precision, well-established significance, and a degree of convenience advanced to the point of greatest efficiency. Usually these analytical procedures have evolved from wet chemical methods which gave quantitative compositional results in terms of decimal fractions of per cent. Such results frequently continue to be reported in the same units because they are universally understood and are suitable for purposes of comparison and for consumer use.

In consumer laboratories such as that at Wright Field there are usually several distinct types of spectroanalysis conducted on a wide variety of matrices. There are qualitative analyses, complete order of magnitude analyses, limited order of magnitude analyses, and quantitative

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analyses. The qualitative analysis report includes all elements detected and a maximum value representative of the sensitivity under the conditions for each element undetected. This maximum value is given in percentage composition but is only an approximation. This type of report is used as a preliminary to work by the chemical unit for samples which are limited in quantity available. Corrosion products are typical samples of this type.

Much more frequently the information requested requires a complete order of magnitude analysis. In this case, the quantity of each element present is estimated to be within one of a logarithmic set of ranges which may be considered orders of magnitude.

	Percentage greater than	Percentage less than
Matrix constituents	10	100
Major constituents	1	10
Minor constituents	0.1	1.0
Trace constituents		0.1

(Maximum order of magnitude value is recorded for traces.)

Borderline elements cause some difficulties since it is virtually impossible to have available for actual comparison analyzed specimens of the wide variety of compositions used. As spectrographic data are accumulated, the opportunities for intercomparison of plates are multiplied. These complete order of magnitude analyses are frequently accepted for the solution of chemical and metallurgical problems without further work. In case additional results are obtained on the sample, the data are returned to the spectrographic file.

The order of magnitude determination is frequently requested for a selected list of elements. The procedure for these elements is the same as that outlined above. Such reports are used for identification, confirmation of samples, and occasionally for lack of conformance to specification requirements.

Quantitative spectroanalysis is limited to those determinations which have been fully studied with analyzed samples throughout the range of composition encountered. For specification conformance it may only be necessary to investigate ranges of concentration near the limits specified. The report of such analyses may be given in terms of maximum and minimum values if analyzed samples do not sufficiently cover the range to justify interpolation. However, they are usually reported in percentage composition with a specified tolerance based on the reproducibility of the standardization curve.

Speed in Spectrographic Analysis

By C. C. Nitchie[1]

One of the outstanding reasons for the rapidly increasing use of spectrographic methods in industrial laboratories is the fact that quantitative analyses of sufficient accuracy for inspection and for production control can be made in much less time than is required for chemical analysis. With the reputation that has been built up for the spectrograph in this respect, metallurgists and engineers who have problems in which it should be useful are sometimes a little puzzled by the fact that the spectrographer cannot always tell them immediately all they would like to know.

It is a common thing to have somebody submit a sample of some peculiar material asking for a spectrographic analysis. He wants to know how much of this, how much of that, and how much of something else is present. The spectrographer has to dissappoint him sometimes because in the time available with a single sample of material he is rather put to it to make even a rough estimate of what the inquirer wants. One of the reasons is indicated by the spectrum of a sample in which several elements are present all at the same concentration. The strongest line of each element is noted and compared with the strongest line of each of the others. It is easy to see that they differ greatly in the way they show up in the spectrum. The magnesium line is very black and stands out prominently whereas a neighboring line representing the same concentration of arsenic is comparatively weak. Copper lines are strong though not so strong as those of magnesium. Nickel, iron, and zinc lines are weaker, while phosphorus lines are even weaker than those of arsenic.

It is entirely possible from the spectra of a series of standard samples of known composition to determine how the line densities for a given element vary with concentration and to prepare working curves from which these concentrations in other samples can be evaluated. These curves will not be the same for different elements nor for the same element in different materials. Consequently, a considerable amount of preparatory work is necessary before a quantitative analysis can be made on any new material for which working curves are not available. Once they have been prepared, an analysis can be carried out very rapidly. This, of course, means that spectrographic quantitative analysis is most useful for routine work in which the same analyses are made repeatedly on the same types of material. High speed in analysis is attainable only after the necessary preliminary work has been completed. If only a single sample is involved the work of standardization may require more time than the chemical analysis.

[1] Bausch & Lomb Optical Co., Rochester, N. Y.

Accuracy Requirements in Analysis

By E. B. Ashcraft[1]

It is the purpose of this paper to discuss briefly the factors which should determine the accuracy required of an analysis. These factors are, or at least should be, obvious, but all too often are not consciously considered. The approach to the problem has been twofold: first, an attempt has been made to consider it fundamentally and determine what generalizations, if any, can be made; second, a number of specific cases have been studied in detail. It was necessary as well as desirable to carry on the latter study by means of conversations with interested individuals since a literature on the subject is almost entirely lacking. A great deal has been written about specifications and about the accuracy and probable error of a set of results but practically nothing about the important question of what accuracy is desirable.

In a logical approach to the problem of accuracy requirements the first question to be put, it seems, should be—why is any analysis to be made? This question is all too often not carefully considered. In general, two types of problem require analytical work. In one, a material, unknown either wholly or in part, is at hand and it is required to determine its composition; this might be termed investigational analysis. In the other, the type of material at hand is known, but analytical work is required to determine whether certain constituents fall within prescribed limits; this is control or inspection analysis. A little reflection will make it evident that both types of analyses require a wide range of accuracies depending on the nature of the specific problem.

Just what are the factors which will determine the desirable accuracy in any specific case? Ideally, it would seem possible to enumerate these factors and deduce certain mathematical relationships between them which would be of general validity. Practically, this is not the case. Examples are so varied and relationships so obscure that it is difficult even to arrive at a satisfactory set of independent variables. Some reflection along these lines can be recommended to anyone who becomes impatient with the difficulty of getting a definite answer to the question of why a requested accuracy is necessary.

However, it is possible to list the more important of these factors affecting accuracy and to show qualitatively the relationships between them. Certainly the first factor to consider and the one which underlies all others (though it is not always predominant) is that one related to the use to which the results of analysis are to be put. This may be called the "use factor" for want of a better term. Usually it is related to some physical or chemical property which is a function of the composition. It should be possible to plot this "use factor" against chemical composition and say in general that as the slope of the curve becomes greater the accuracy of the analysis must increase for a given tolerance in the "use factor." It is surprising how difficult it is to find clear-cut examples of the dependence of a "use factor" on composition and how much more difficult it is to find examples of logical tolerances in the "use factor."

A concrete example where such data are available is the determination of silicon in the charge to be added to a bessemer converter. Thermochemical calculation shows that when the total silicon content is about 2 per cent a variation of about 3 per cent of the amount present will change the temperature in the converter by 20 to 25 F. When it is realized that the temperature range employed is very narrow (about 200 F.) with its upper limit fixed by the resistance of the refractory and its lower by the pouring and cooling characteristics of the metal, the desirability of an accuracy of the order mentioned is recognized.

In many instances other factors will outweigh the "use factor" and make it desirable either to raise or to lower the tolerance. For instance, the properties of a vanadium steel are not very critically dependent on the amount of vanadium present above a certain minimum. From the standpoint of use a minimum go-no-go analysis is sufficient. However, vanadium is a relatively expensive metal and the factor of economy makes a more accurate analysis desirable in order to avoid needless waste of material.

The factor of speed is closely associated with that of economy and is often predominant in determining the requisite accuracy. The necessity for rapid analyses is particularly evident in modern metallurgical practice such as the production of alloy cast irons and steels by a continuous rather than a batch process. It has been stated as a general rule in this case that the greater the speed with which an analysis can be made, the greater the possibility of accurate control of the steel-making operations. Often it is possible to increase the speed of analysis without loss of accuracy. But many times when this is not the case, it is desirable to sacrifice accuracy in order to attain greater speed.

Useful generalizations are almost entirely lacking in this problem of accuracy requirements; each case requires individual treatment and the desired accuracy will be an optimum value, a compromise, which can only be reached by careful consideration of a number of factors, chief of which are the use to which the material is to be put, the speed necessary, and economies which can be effected.

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Reproducibility in Spectrochemical Analysis

By A. E. Ruehle[1]

In speaking of reproducibility in spectrochemical analysis one must immediately specify the type of application involved. To the experienced spectroscopist, essential differences are apparent between such problems as production control analysis of a particular alloy for definite elements in specified ranges and consumer analysis of run-of-the-mill samples of unknown composition.

In the first case very high reproducibility as well as high speed can be attained, particularly if spark excitation is applicable. Since spark circuit conditions can be closely controlled and since the spark does not heat the point of discharge to incandescence one can often obtain lines of reproducible density with no adjacent background. This may be regarded as a close approach to ideal conditions, and it is not surprising that reproducibilities of the order of 10 to 30 parts per thousand have been reported. We have obtained reproducibility of this order of magnitude in the analysis of a lead alloy using the controlled spark method of excitation. The residual errors in such a case may be attributed at least partially to variability in plate sensitivity and densitometry as well as to variable excitation.

In the consumer type of analysis where the volume frequently does not justify the development of spark methods the major variables are unquestionably associated with excitation although in some cases measurement errors also play an important role. This is shown by the uniformly lower reproducibility of arc methods. For example, we have obtained a precision of 50 to 100 parts per thousand using the arc method for solutions or powders on alloys of aluminum, copper, iron, lead, nickel, silver, tin, and zinc. In a few cases where we have had the most experience and where plate background is virtually absent, we have reached 40 parts per thousand, but we have never attained reproducibility comparable to that of the spark method, even though modern methods of photometry were utilized. Our experience with the arc using self-electrodes or metallic globules is limited but is not such as to promise better results than those obtained with solutions or powders.

At the same time by visual comparison of lines a reproducibility of 100 to 200 parts per thousand is usual, so that one must conclude that measurement as well as excitation errors are involved in such methods. In certain cases where the density of the impurity lines is only slightly greater than the density of a variable background it is true that visual comparison by an experienced operator is the most reliable method of spectrum line photometry, so that one should not be too quick to disdain any particular procedure without due consideration of the factors involved.

The following are typical results:

Matrix	Impurity	Range, per cent	Source	Photometry	Background	Reproducibility, parts per thousand[a]
Pb	Ca	0.01 to 0.1	Standard alloys—controlled spark	Internal control—calibration	None	About 20[b]
Pb	Sn	0.001 to 0.3	Solutions—arc	Internal control—calibration	Low	40
Ni	Mg	0.003 to 1.0	Solutions—arc	Internal control—calibration	Low	65
Fe	Cu	0.001 to 1.0	Solutions—arc	Internal control—calibration	Low	80
Zn	Pb	0.001 to 0.1	Solutions—arc	Comparisonstandard — densitometer	Low	90
Pb	As	0.01 to 0.3	Powders—arc	Internal control—calibration	Moderate	100
Pb	As	0.001 to 0.01	Powders—arc	Comparisonstandard—visual	Moderate	200
Al	Zn	0.02 to 1.0	Powders—arc	Internal control—calibration	Moderate	100
BeO	SiO_2	0.1 to 5.0	Powders—arc	Comparisonstandard—visual	High	200

[a] Average deviation.
[b] Still under investigation.

These examples serve to illustrate the effects of excitation method, photometry method, and relative background density on reproducibility in spectrochemical analysis. Highest reproducibility can be attained using controlled spark excitation and internal control photometry with plate calibration. The application of this method is limited, however, by low spectral sensitivity, possibilities of gross errors due to nonuniformity of samples, difficulties in preparing and standardizing standards, and difficulties in obtaining comparable electrode forms in samples and standards. Hence in many cases, especially in analysis from the consumer's standpoint, one must be content with the lower reproducibility of arc excitation. Here background is always higher and this may further reduce the reproducibility possibilities if it becomes appreciable. Even under the most disadvantageous conditions, however, one may set 200 parts per thousand as the ordinary limit of the reproducibility obtainable by spectrochemical analysis if care is exercised to avoid the pitfalls leading to gross errors.

[1] Bell Telephone Laboratories, New York, N. Y.

Method of Testing Spectroscopic Carbons

By H. G. MacPherson[1]

CONSIDERABLE work was done in December, 1939, to determine the best procedure for testing spectroscopic carbons. For this experimental work some 5/16-in. graphite rods were used which contained small amounts of impurities in the same chemical form in which they would occur in spectroscopic carbons. Spectroscopic carbons could not be used for this work since they were too pure to assure the presence of elements in the tests. Impregnating spectroscopic carbons with known amounts of impurity was avoided because previous work had shown that the impurities obtained by such impregnation were evaporated more rapidly in the arc than impurities naturally occurring in the carbons.

In these tests the cathode layer and part of the arc stream were focused on the slit of the spectrograph. Process plates were used and most of the exposures were made so as to give a fairly dark background density for the cathode layer region. The factors tested were the current in the arc stream, the length of the arc gap, and the time of exposure. Due to unevennesses in the impurity content of the different carbons used, the results obtained on any one plate could not be completely trusted. However, the results from a number of plates testing the same factor allowed certain conclusions to be drawn:

1. *Current.*—It was shown definitely that the detection of lead, which was present in very minute amounts, was much more sensitive at higher currents in the range around 10 to 20 amp. than it was at lower currents of about 10 amp. Manganese and possibly some other impurities showed some tendency to be more easily detected at the higher currents. However, for most of the elements present in greater abundance the sensitivity of detection was found to be almost indifferent to the current used provided sufficient exposure was made to obtain the same background blackening on the plate.

2. *Arc Gap.*—It was shown that the detection of impurities was definitely more sensitive when arc gap lengths of 6 mm. or more were used than when gaps of 4 mm. or less were used. Between the range of 6 and 20 mm. there was little apparent difference in the detection of impurities, although there was some indication that the longer arc gaps of 10 mm. or over might be better than a 6-mm. arc gap. These tests were all made at a current of around 20 to 22 amp. and with the positive electrode placed below the negative electrode. The greater sensitivity of detection of impurities at arc gap lengths of 6 mm. or greater seems contradictory to some published work. However, the published work deals with impurities introduced into a hole in the top of a positive electrode and here we are concerned with impurities distributed uniformly throughout the carbon. Impurities evaporated from the sides of the carbon must be able to diffuse back into the arc stream in order to be registered on the photographic plate and apparently this can be done best when the arc gap length is greater than 6 mm.

3. *Time of Exposure.*—Several tests were made using successive equal length exposures of the same electrodes to determine the apparent vaporization time of the impurities in the electrodes. The most general result found was that the first 15 sec. are less effective than the subsequent intervals. This is undoubtedly because it takes 10 to 15 sec. to heat up the carbons. The strength of the lines of elements occurring in appreciable quantities showed approximate indifference to the time of burning of the arc for periods up to about 120 sec. except for the first few seconds as noted above.

As a result of these tests the method of testing spectroscopic carbons was changed as indicated in Table I.

TABLE I.—APPROXIMATE CONDITIONS OF EXPOSURE, NEW AND OLD METHODS OF TESTING.

	New Method	Old Method
Current	20 amp.	8 amp.
Carbon trim	Pos. below; Neg. above	Pos. above; Neg. below
Exposure time	50 sec.	100 sec.
Slit width	0.025 mm.	0.030 mm.
Density of background	About 1.0	About 0.3
Arc gap	8 mm.	Haphazard

The carbon trim was changed so that the positive carbon was the lower carbon. The reason for this was theoretical. Since the positive carbon becomes more highly heated, more impurity vapors can be expected to be given off from the positive. These vapors will be carried up through the arc stream and with the positive below more of them will appear in the spectrum of the arc stream. The exposures were made heavier largerly by the increased current so that the continuous spectrum background density was increased from a light gray to a dark gray. It appeared from the tests that it was easier to detect the presence of faint impurities with the higher background density.

A comparison of the new and old methods of testing spectroscopic carbons was made using some of the special spectroscopic carbons. The carbons were run according to the usual technique and the reports were made out with an attempt to duplicate the standard procedures. The results of these tests are reported in Table II.

TABLE II.—COMPARISON OF LINE INTENSITIES UNDER NEW AND OLD METHODS OF TESTING SPECTROSCOPIC CARBONS.[a]

Carbon sample...	5/16-in. Graphite				1/4-in. Graphite				5/16-in. Carbon			
Method of test...	New	New	Old	Old	New	New	Old	Old	New	New	Old	Old
Trial...	1	2	1	2	1	2	1	2	1	2	1	2
Impurity:												
Aluminum	0	0	ab	ab	0	1	ab	ab	ab	0	ab	ab
Lead	0	0	ab	ab	ab	0	ab	ab	ab	ab	ab	ab
Magnesium	3	3	1	1	3	3	ab	ab	3	2	2	0
Manganese	2	3	ab	ab	2	2	ab	ab	3	2	1	0
Silicon	1	1	ab	ab	0	0	ab	ab	0	ab	ab	ab

[a] ab = absent; 0 = barely visible; numbers indicate relative intensity.

The increase in sensitivity of detection of these trace elements was found to be much greater than expected on the basis of the experimental work done with carbons containing a higher amount of impurity. Examination of the table shows that with the same carbons the line intensities are found to be one to three points greater by the new method. The increase in sensitivity caused by the increased arc current is in agreement with the experience of D. W. Armstrong of the National Health Institute in the detection of minute traces of impurity.

[1] Research Laboratory, National Carbon Co., Inc., Cleveland, Ohio.

The Validity of Spectrochemical Analysis Conducted According to the Tentative Method E 26 – 35 T

By M. L. Fuller[1] and G. W. Standen[1]

This discussion is intended to provide the session, on "Accuracy Requirements *versus* Reproducibility Possibilities," of the symposium with a factual report of the validity of industrial spectrochemical analysis of zinc by the A.S.T.M. Tentative Method of Test for Quantitative Spectrochemical Analysis of Zinc for Lead, Iron, and Cadmium (E 26 – 35 T).[2]

The discussion is presented in two parts:

1. "A test of the accuracy of the determination of cadmium in zinc on the basis of repeated determinations on a sample of known cadmium content."

This test indicated that the errors in this determination do not exceed 10 per cent of the amount of cadmium in the sample 95 per cent of the time.

2. "A comparison between spectrographic and chemical determinations of lead in zinc on a large number of different samples."

These check determinations were made on zinc having lead contents ranging from 0.0015 to 0.0030 per cent and demonstrated that the agreement between the two methods is such that determinations by the two methods are not likely to differ from one another by more than 20 per cent for 89 per cent of the time. The determinations by the two methods were made independently by two separate laboratories within The New Jersey Zinc Co. and the deviations experienced were those to be expected from the combined errors of the two methods.

Test of the Accuracy of the Determination of Cadmium in Zinc on the Basis of Repeated Determinations on a Sample of Known Cadmium Content

In order to obtain knowledge of the accuracy to be expected in the routine practice of the spectrochemical analysis of zinc according to the Tentative Method E 26 – 35 T, repeated determinations of the cadmium content of a single sample were made. The sample was prepared as a synthetic solution of pure zinc and cadmium made to a concentration of 0.0750 per cent cadmium in zinc.

Nineteen spectral plates were prepared from this one solution according to the procedure required by the method (E 26 – 35 T Section 5*a*, *b*, *c*). The cadmium content of the sample was estimated on each plate independently by two observers. The work was arranged so that the observers had no knowledge of the synthetic composition of the sample, and the work was interspersed with the routine work of the laboratory.

The average of the estimates of the two observers for one plate was taken to be the cadmium content as evidenced by that plate. These values are listed in Table I. The 19 plates show an arithmetic mean of 0.0756 per cent. The mean value is in close agreement with the synthetic composition of 0.0750 per cent cadmium.

The problem is to determine from the data of these 19 plates what degree of reliability can be placed upon a determination made in the usual way according to the A.S.T.M. method requiring that two plates shall be prepared and averaged in analyzing any one sample.

The total number of plates (19) and the number of plates to be averaged in analytical work (2) are too small to permit treatment of this problem by the usual methods of statistical analysis. However, by combining these 19 determinations two at a time, 171 determinations based on the averages of two plates each may be written down. These represent the 171 possibilities in which these 19 plates could have been used to indicate the cadmium content of this sample. Table II lists these data together with the percentage by which each determination deviates from the arithmetic mean.

Combining the positive and negative values in order to determine what percentage error may be expected from spectrochemical determinations by this method, Table III has been prepared.

Plotted for cells of 2 per cent each, the frequency plot of Fig. 1 is obtained.

Twenty-three per cent of the determinations are in error by 2 per cent or less, 74 per cent by 6 per cent or less, and 95 per cent by 10 per cent or less. Only 5 per cent of the 171 possible determinations differ from the mean by more than the 10 per cent precision claimed for the method by Note 7 of the Tentative Method E 26 – 35 T.

The foregoing analysis of the errors is based on the arithmetic mean value of 0.0756 per cent. Strictly speaking, therefore, the errors found do not indicate the abso-

TABLE I.—RESULTS OF DETERMINATIONS OF CADMIUM CONTENT OF ONE SAMPLE.

Plate	Cadmium, per cent	Plate	Cadmium, per cent
No. 1	0.070	No. 10	0.070
No. 2	0.070	No. 11	0.078
No. 3	0.073	No. 12	0.078
No. 4	0.080	No. 13	0.075
No. 5	0.070	No. 14	0.060
No. 6	0.078	No. 15	0.078
No. 7	0.083	No. 16	0.080
No. 8	0.078	No. 17	0.070
No. 9	0.080	No. 18	0.080
		No. 19	0.085

TABLE II.—ONE HUNDRED SEVENTY-ONE POSSIBLE CADMIUM DETERMINATIONS BASED ON 19 SPECTRAL PLATES TAKEN TWO AT A TIME.

Cadmium, per cent	Number of Determinations	Deviation from Mean, per cent
0.0840	1	+11.1
0.0825	4	+ 9.1
0.0815	9	+ 7.8
0.0805	5	+ 6.5
0.0800	7	+ 5.8
0.0790	22	+ 4.5
0.0780	11	+ 3.2
0.0775	9	+ 2.5
0.0765	14	+ 1.2
0.0755	5	− 0.1
0.0750	20	− 0.8
0.0740	26	− 2.1
0.0725	6	− 4.1
0.0715	6	− 5.4
0.0700	14	− 7.4
0.0690	5	− 8.7
0.0675	1	−10.7
0.0665	1	−12.0
0.0650	5	−14.0
	Total 171	

[1] Research Division, The New Jersey Zinc Co. (of Pa.), Palmerton, Pa.
[2] A.S.T.M. Methods of Chemical Analysis of Metals, p. 239 (1939).

TABLE III.—ERRORS IN 171 DETERMINATIONS OF CADMIUM CONTENT.

(Mean Value 0.0756 per cent Cadmium)

Percentage Error (from Mean)	Number of Determinations
0 to 1	25
1 to 2	14
2 to 3	35
3 to 4	11
4 to 5	28
5 to 6	13
6 to 7	5
7 to 8	23
8 to 9	5
9 to 10	4
10 to 11	1
11 to 12	2
12 to 13	0
13 to 14	5
Above 14	0
Total	171

lute accuracy of the method. Since, however, the actual percentage of cadmium in the test solution was known to be 0.0750 by synthesis, the analysis of the errors is virtually the same as if it had been referred to the actual cadmium content of 0.0750 per cent.

An exactly similar test of accuracy has not been made at other concentrations of cadmium but it is the opinion of the authors based on extensive use of spectrographic methods of analysis that the relative error is the same at all concentrations. The principal source of error appears to be in the excitation of the spectrum itself and not in interpreting the finished spectral plate.

Comparison Between Spectrographic and Chemical Determinations of Lead in Zinc on a Large Number of Different Samples

A large group of data was available in which the lead content of 127 samples of zinc had been determined by both chemical and spectrographic methods. The spectrographic determinations were made according to the Tentative Method E 26 – 35 T and the chemical determinations were made by the electrolytic method.

The 127 check determinations are listed in Table IV.

In order to analyze these data, the percentage of the lead content, as determined by the chemical method, by which the spectrographic lead content differed, was calculated for each case. These percentage differences are presented graphically as a frequency plot using cell intervals of 5 per cent, in Fig. 2. The agreement between the two methods is such that:

61 per cent of the cases show agreement between the two methods of 10 per cent or less,

89 per cent of the cases show agreement between the two methods of 20 per cent or less,

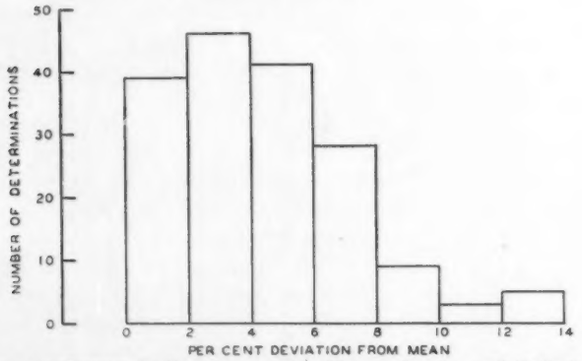

Fig. 1.—Errors in Spectrographic Determination of Cadmium in Zinc.

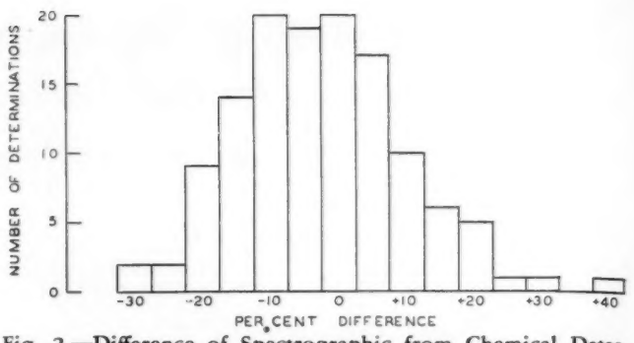

Fig. 2.—Difference of Spectrographic from Chemical Determination of Lead in Zinc.

127 different samples ranging from 0.0014 to 0.0031 per cent by chemical analysis and 0.0015 to 0.0030 per cent by spectrographic analysis.

11 per cent of the cases differ by more than 20 per cent.

The frequency plot is not symmetrical about the center of the graph but is symmetrical at a point on the negative side of the center at approximately −2.5 per cent. This indicates that the spectrographic determination tends to be 2.5 per cent less than the chemical determination. It is not possible from these experiments to assign a reason for this tendency toward a constant difference of 2.5 per cent. For all practical purposes this error is not significant, however, in the evaluation of lead contents of zinc ranging from 0.0015 to 0.0030 per cent.

The errors inherent in the chemical method become increasingly great as the concentration of the element to be determined becomes less, in contrast to the spectrographic method for which the relative error remains the same at all concentrations. It is the opinion of the authors and of the chemists who performed the chemical analyses that the differences between corresponding determinations by the two methods on one sample is what might be expected from the combined errors of the two methods.

Acknowledgment:

The cooperation of the Testing Department of The New Jersey Zinc Co. in making available to us the chemical determinations of lead is greatly appreciated.

TABLE IV.—COMPARISON BETWEEN SPECTROGRAPHIC AND CHEMICAL DETERMINATION OF LEAD IN ZINC.

Lead, per cent × 10^4

Chemical	Spectrographic	Chemical	Spectrographic	Chemical	Spectrographic	Chemical	Spectrographic
21	18	22	19	24	22	21	25
16	18	20	20	26	22	26	20
21	18	17	19	24	21	21	20
19	20	23	18	26	24	19	20
22	20	17	18	23	21	22	21
22	19	23	19	27	27	21	20
20	16	19	20	29	29	20	18
18	20	20	19	31	29	19	15
21	18	21	22	30	30	21	18
20	18	21	19	25	23	22	15
19	19	18	23	27	21	22	26
19	17	20	17	24	22	23	24
19	18	17	18	21	25	21	25
24	17	16	17	23	23	22	24
23	18	14	16	18	19	26	25
18	19	18	18	24	23	29	30
22	20	23	28	26	24	23	19
19	20	20	20	22	25	26	23
18	18	18	20	21	23	24	23
22	18	18	18	25	25	25	25
19	23	19	19	25	24	25	24
20	20	19	20	24	22	27	24
19	19	18	19	23	20	22	24
20	19	18	25	23	20	27	24
21	19	21	22	27	21	25	27
21	17	25	23	25	25	24	24
23	27	22	25	27	25	23	29
21	21	26	28	19	18	27	21
20	19	24	24	22	21	25	24
21	20	24	20	20	18	21	22
18	21	27	28	25	22	21	19
20	20	29	25	21	23		

Some Causes of Nonreproducibility in Spectrochemical Methods—Emphasizing the Effect of Preheating on the Determination of Zirconium in Iron Oxide

By Lester W. Strock[1]

Spectrochemical determinations are extremely simple in principle and the lyrical persons, mentioned by Mr. Wright[2] can justly acclaim as specific advantages, among others: the (1) minute sample employed, (2) the low concentration of impurities detectable, (3) speed, and (4) the permanent record of the analytical data in the spectrogram. Practically all spectrochemical methods at present are based on a comparison of *unknown* with *known* concentrations of a given element in otherwise comparable samples. In the more quantitative procedures, the density of a spectral line or other related photometric value, such as opacity, transparency, or galvanometer deflection, is converted to a corresponding intensity value relative to that of some line whose intensity may be used as a standard in any particular problem. The resulting intensity ratios from a series of known samples are then used to construct a working curve for analyzing unknowns—naturally the concentration in the unknown must fall within, or be adjusted to, the range over which the curve was constructed.

The ever-increasing application of spectrochemical methods for accurate and rapid determinations of minor elements in industrial products is due to the fact that reproducible and accurate working curves can be obtained for many elements. The author's (*1*, *2*)[3] determination of lithium in geological materials illustrates both the concentration range and accuracy obtainable in d. c. arc methods. In this particular case the percentage of Li_2O was determined to within 3 per cent of the amount present over the range 0.0002 to 3 per cent. An unpublished method for determining tin in oxidized iron ores and Fe_2O_3 has given even better results.

The above-mentioned favorable examples naturally involve many sources of error, of which personal technique and unexpected contamination during the handling of mixtures or precipitates are important ones. In the above-mentioned examples, Li absorbed by an agate mortar, and Sn from redistilled water (tin-lined still) were especially troublesome. These and other factors can be, and were, eliminated when recognized, although similar factors may impose serious limitations on specific application of spectrochemical methods. However, cases are met with in which extremely poor reproducibility cannot be attributed to such simple causes. The factors involved are then obviously more fundamentally rooted in the basic operations of the spectrochemical method, such as (1) the photographic process, (2) the arcing or sparking process, or (3) even to an erroneous analysis of the photometric data. The first factor has been studied in some detail from a spectrochemical point of view by the author.

This study has revealed a previously unrecognized photographic effect whereby the rate of development of a spectral line (or any latent image) depends on the intensity level of exposure in such a manner that faint lines develop to their maximum density in a shorter time than do strong ones provided their intensity is below a given critical value which varies with the emulsion type. A new theory of the latent image and development process was derived to account for this effect. The experiments and theoretical treatment are published in a monograph (*3*) of the Norwegian Academy of Science. The relation of the photographic process to quantitative spectrochemical methods has been discussed in other publications (*4*, *5*, *6*). An immediate practical result of these photographic studies is that weaker lines may be more advantageously utilized, thus permitting more accurate determinations of lower concentrations. Even yet it is not possible to give a general method for correcting the effect of the spectrum background, as there are many factors concerned which combine differently even in closely related practical cases.

Reference should be made to two figures (Figs. 5 and 7) in one of the above-cited papers (*4*) which illustrate the manner in which four known photographic effects can conspire to alter an otherwise linear working curve. One of the curves is reproduced here as Fig. 1 to emphasize the practical importance of the background effect when faint lines are utilized. The solid line curve represents an analytical "working" curve whose irregular shape is caused by the Eberhard and background effects. The flat

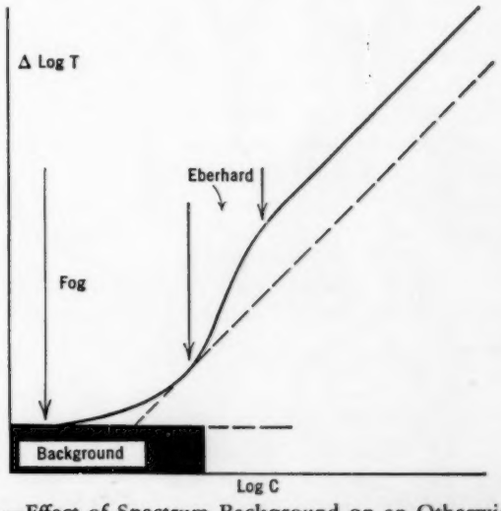

Fig. 1.—Effect of Spectrum Background on an Otherwise Linear Concentration Curve Derived from Faint Spectral Lines. Δ Log *T* Is Expression of Intensity Ratio and Obtained from Experimental Curves as Shown in Fig. 2.

(L. W. Strock, *Proceedings*, Seventh M.I.T. Conference on Spectroscopy.)

[1] New York State Research Institute of the Saratoga Spa, Saratoga Springs, N. Y.

[2] Thomas A. Wright, "Variables *versus* Constants in Emission Spectrography," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1355 (1940).

[3] The italic numbers in parentheses refer to the reports and papers appearing in the list of references appended to this paper.

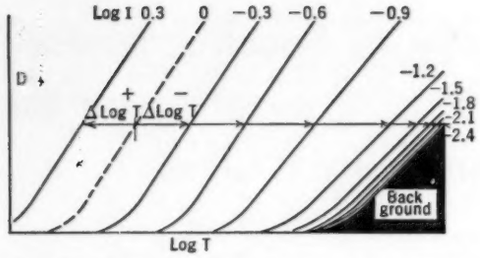

Fig. 2.—Family of *D*–log *T* Curves for Lines Differing by a Constant Intensity Factor. Note Asymptotic Fading into Background.

(L. W. Strock, *Proceedings*, Seventh M.I.T. Conference on Spectroscopy.)

lower portion due to the spectrum background is most troublesome at the lower limit of photographic detectability of faint lines. This is caused by the manner in which a line on becoming progressively weaker, only slowly fades into the background as shown by Fig. 2,[4] also taken from the same paper. In this figure the density-log exposure time curves were obtained from lines of different intensity by means of a step sector. The only *cure* for the background effect at present is to prevent it. The density of the background must be kept down by all possible means when dealing with weak lines. This will not cause a corresponding density loss of the weak line itself, as the higher contrast of the line is preserved, and not destroyed by a blocking of the Eberhard effect by the fog.

Many investigators (7) have carried out fundamental studies on the arcing and sparking process with special emphasis on the practical spectrochemical aspect of the problem, in which the mechanics of light emission, arc temperatures, electrolytic migration in the arc, and current-voltage relation, etc., were stressed. There are various limitations on spectrochemical methods explainable on the basis of these physical factors. Very definite limitations on reproducibility and sensitivity occur at times, however, which are caused by more purely chemical factors. The sample heated in the crater of an electrode behaves as if it were in a very high temperature microfurnace, where chemical reactions can occur which have a decided influence on the subsequent physical process which causes the emission of spectral lines.

One of the chief purposes of this symposium is to acquaint the engineer with occasional difficulties and limitations of accuracy and reproducibility in spectrochemical analysis. Accordingly the following experimental data are presented in order to offer a specific example of these occasional difficulties caused by some of the above-mentioned factors.

These data were obtained in devising a method for determining traces of Ti, V, and Zr in Saratoga natural mineral waters. One of these waters contains approximately 15,000 mg. solids per liter, consisting of Ca, Mg, Na, and K as bicarbonates and chlorides. A few milligrams of Fe per liter are also present. After destroying the carbonates with HCl, the water can be concentrated to approximately $^1/_{20}$ volume without depositing solids.

The method for determining Ti, V, and Zr which suggested itself was to concentrate the acidified water to $^1/_{15}$ volume and precipitate the Fe with some reagent which simultaneously precipitates the Ti, V, and Zr, thus separating the Fe and these trace elements from the 3000 times greater amounts of other salts. In practice 7.5 liters of water were just neutralized with HCl, then concentrated to 500 ml. This was adjusted to contain 5 per cent HCl, and the 35 to 40 mg. Fe precipitated by cupferron and thus separated from the approximately 100 grams chlorides of Na, K, Ca, and Mg. This precipitate could be washed practically spectroscopically clean of Na, Ca, and Mg, and on ignition yielded Fe_2O_3. The problem then was to make a spectrographic determination of Ti, V, and Zr in the Fe_2O_3.

The difficulties to be described were encountered in analyzing synthetic test solutions, preparatory to actual work on Saratoga water. The first series of test solutions contained Ti, V, and Zr (ranging from $^1/_{64}$ to 1.0 mg.) all in equal amounts, plus 25 mg. Fe. The chief difficulties to be stressed below were obtained, however, from a second series of experiments in which zirconium alone was precipitated with iron from test solutions.

Duplicate precipitations were made at some concentrations, and several duplicate spectra photographed of each precipitate—some on different plates. Figure 3 shows the widely scattered individual values of the intensity of the Zr lines relative to the Fe lines. The individual values within an enclosure were obtained from the same photographic plate designated by the numbers in the figure, and for the greater part from the same precipitate. The maximum deviation of approximately $\Delta \log T = 0.3$ (equal to a whole sector step) was just as frequently shown in one of the duplicate or triplicate spectra of the same precipitate on the same plate as for different precipitates and different plates. Now it is known that all electrodes used for spectra on plates above No. 64 were decidedly less porous than those used for earlier plates, and this was at first thought to be the source of the bad reproducibility. The points obtained from the first two plates (Nos. 64

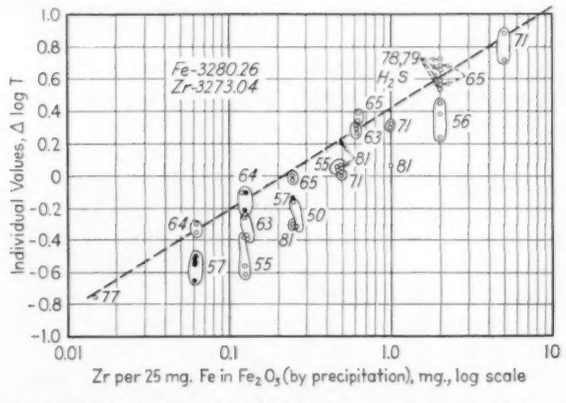

Fig. 3.—Widely Scattered Individual Intensity Ratio Values (Expressed as Δ log *T*) of Fe : Zr, from Several Arc Spectra of Ignited Cupferron Precipitates of 25 mg. Fe and *x* mg. Zr from 250 ml. Test Solutions.

Numbered enclosures refer to same plate. Spectral lines Zr 3273.04 Å and Fe 3280.26 Å used.

[4] Figure 2 also illustrates the general manner of determining a practical numerical index of the intensity ratio of two lines from photometric curves obtained, for example, from stepped spectra. This index is Δ log *T* and is the horizontal separation of *any* curve from *the* curve for the line whose intensity is taken as intensity standard. Δ log *T* is nearly equal to intensity ratio (*I*) in most practical cases. This separation plotted against concentration provides an analytical working curve, no matter whether the ordinates be density, opacity, transparency, or galvanometer deflection. The unit in which the photometer data is plotted may be a personal preference or dictated by factors inherent in the problem. Where speed is an essential requirement, it is recommended and usually customary, that galvanometer deflections be plotted directly on semi-logarithm paper, having adjusted the clear film deflection to some constant value.

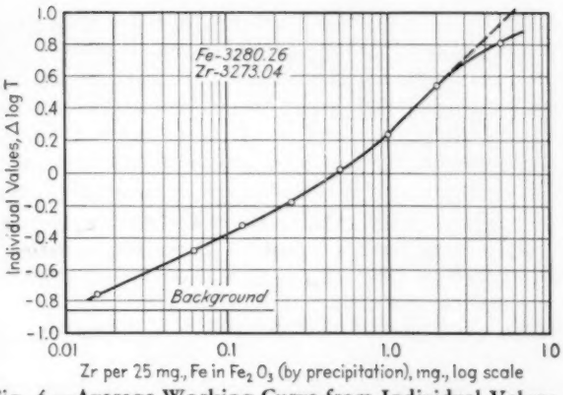

Fig. 4.—Average Working Curve from Individual Values of Fig. 3.

and 65), using the more compact carbons, yielded a reasonably good linear relationship between Δ log T and Zr concentration. The dashed line in Fig. 3 represents the average curve obtained from them. However, the "*final*" plate to get better averaged values for locating the linear relation more exactly, yielded the most erratic values so far obtained. In fact, two of the mixtures (0.25 and 1 mg.) on plate No. 81 provided a second linear relationship parallel to the first, but displaced to include the extreme variation of the discarded values obtained with definitely porous carbons. It must be noted that duplicate values for the same mixture often check each other very closely, and at the worst have a spread in Δ log T = 0.2 (once = 0.24), whereas at 0.125 mg. Zr a spread of 0.51 was obtained from different plates.

The above results indicate plainly that some seemingly insignificant factor in the arcing technique is capable of producing intensity fluctuations over a wide range. In spite of the wide spread of the individual values, the average of all spectra of these precipitates falls on the rather smooth curve shown in Fig. 4. This curve has very little practical value, however, due to the widely fluctuating individual values involved.

In order to emphasize to the practical engineer that such unexpected and perplexing fluctuations can occur and seriously limit certain applications of spectrographic analysis, the above presentation of some actual objective experimental data might suffice. However, an obvious reason for this trouble is indicated by the results of some other experiments, and it seems appropriate to place on record in this symposium the following indicated cause of the bad reproducibility obtained.

Figure 5 contains the concentration curves obtained from two series of mechanical mixtures of the dry oxides—curve *A* of Zr + Ti + V in ratio 1:1:1 in Fe_2O_3 and curve *B* of Zr alone in Fe_2O_3. These two series are thus the counterparts of the two series involving precipitated mixtures. These curves are based on fewer spectra than are those for the precipitated mixtures, but the close checks of duplicate spectra and the smooth curves obtained, offered no ground for suspecting that erratic values would be obtained from additional spectra of these oxide mixtures.

The spectrum background involved in these two curves is unfortunately not the same, but it is very probable that both curves would be nearly parallel and practically identical at concentrations below 1.5 per cent ZrO_2, if the backgrounds were equal; since for a pure background effect a line at Δ log T = 0.3, and higher, above the background is not noticeably affected. Above 1.5 per cent ZrO_2, however, the presence of $TiO_2 + V_2O_3$ retards the rate of evaporation of ZrO_2 and thus decreases the Zr-line intensity. There is no indication that curve *A* will become steeper and parallel with curve *B* at higher ZrO_2 concentration. The higher lines *D* and *C* in Fig. 5 are the average and approximate upper limit of the individual values for the Zr-alone precipitated mixtures, respectively. As can be seen, the minimum individual values for the precipitated mixtures approach those obtained from the dry oxide mechanical mixtures as a limit. In fact, the average precipitated mixture curve *D* shows a trend to curve *B* at higher concentrations, and curve *C* is approximately parallel to a large section of curve *A* and thus of curve *B* (when corrected for background).

The cause of the trouble encountered is strongly indicated by a closer examination of these curves; bearing in mind the chemical processes which occur in a micro-high-temperature furnace such as a short-circuited, or arcing, pair of carbon electrodes into which are packed the above mixtures intimately admixed with twice their weight of carbon powder. The position of curve *C* relative to curve *A* (or some of curve *B*) means that the strength of the Zr lines relative to Fe lines is much stronger in spectra of the precipitated mixtures than in the dry oxide mixtures. In these experiments this means that Zr is able to reach the arc gas column in greater concentration from the precipitated mixtures contained in the electrode crater. The Zr is, therefore, more readily volatilized from the precipitated mixture and dissociated into the atomic state, or else dissociated more readily by a chemical reaction in the heated electrode to metallic Zr and volatilized as such. Both processes furnish more Zr vapor to the arc column and lead to the emission of more intense spectra lines from the precipitated mixtures. Now a critical analysis of the gravimetric data indicates that the composition of the ignited precipitates containing Fe + Zr is a mixed crystal of $FeZrO_3$ and Fe_2O_3. The precipitated mixture is apparently a zircono-ilmenite similar to the corresponding oxide of iron and titanium, rather than a mixture of the individual oxides $Fe_2O_3 + ZrO_2$.* The zirconium compound ($FeZrO_3$) melts and volatilizes into the arc at a much lower temperature than would ZrO_2. Simultaneously with this vaporization, the $FeZrO_3$ is undoubtedly partially reduced by the carbon present, yielding metallic ferro-zirconium, which likewise vaporizes into the arc. In the ZrO_2 mixtures, the zirconium is combined in a compound which melts at 2950 C. or 800 C. higher than the metallic Zr itself—moreover, it vaporizes much less rapidly than metallic Zr. This is known from lamp filament work (*8*). In addition, ZrO_2 when heated with carbon is readily transformed to a very stable carbide ZrC, which on melting dissolves more Zr. When arced in air, as in the present

* The radius of the Zr^{+4} ion (0.87 Å) is most likely too large to permit the formation of a stable Fe_2O_3, in which Fe^{+3} (radius 0.67 Å) is replaced by Zr^{+4} in a random manner. A random substitution of Fe^{+3} by Zr^{+3} is even less likely because of their still greater differences in size. The former type of substitution would leave one-quarter of the substituted lattice points in Fe_2O_3 unoccupied, as 4 Fe^{+3} ions are electrostatically equivalent to 3 Zr^{+4} in the lattice. The size of the Fe^{+2} ion (0.83 Å) and the Zr^{+4} ion (0.87 Å) are very similar so they could be expected to substitute for one another in the ratio two Fe^{+2} to one Zr^{+4}. It is easily possible that zirconium in the ignited cupferron precipitate exists as $Fe^{+2}Zr^{+4}O_3$ (zircono-ilmenite) which forms a solid solution with Fe_2O_3. This possibility, as mentioned above, is also indicated by the gravimetric results.

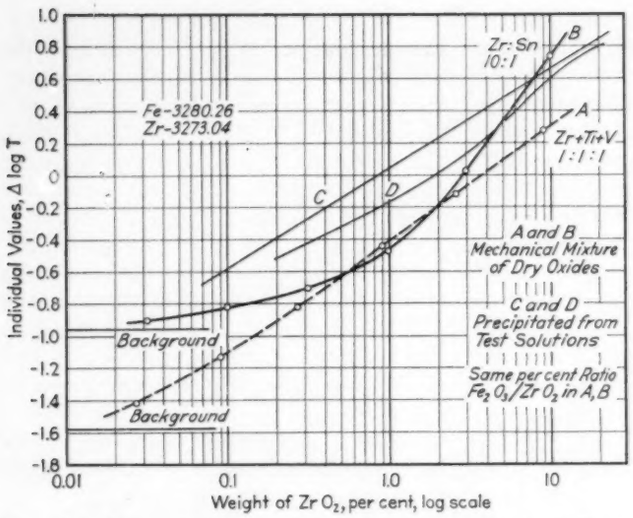

Fig. 5.—Comparison of Working Curves Derived from Mechanical Mixtures of Dry Oxides *versus* Mixtures Precipitated from Test Solutions—Due to Difference in Nature of Samples and Not to Precipitation Loss.

experiments, ZrC is transformed to the still more stable silver-colored nitride. The formation of the nitride means a total fixation of the Zr as far as the formation of spectral lines is concerned, for it is so stable at the arc temperature that it will not dissociate to supply Zr vapor to the arc gas. The chances of Zr escaping from the mixture into the arc gas and thus emitting spectra lines are, therefore, much less when combined as ZrO_2. The carbon electrodes and admixed carbon powder further aggravate the difficulty. On the other hand, when present as $FeZrO_3 + Fe_2O_3$, the process of evaporating a ferro-zirconium after reduction, as well as vaporizing directly as $FeZrO_3$, are very much more favorable. The separation of the curves for the two cases, that is, curves *C* and *A* (or *B*), shows that the amount of Zr reaching the arc column is 6 times less when present as ZrO_2.

Bearing in mind these possibilities, and weighing the notes kept on "minor" points concerning the operating technique of certain plates, it seems that the cause of the erratic individual data for the precipitated mixtures is as follows: The zirconium was present in two distinctly different states of combination at the beginning of the actual arcing process of individual samples, the one extreme being as ZrO_2 and the other as an integral constituent of iron oxide—presumably $FeZrO_3$ (zirconoilmenite), the former producing Zr lines of lowest intensity (arc and spark lines alike) and the other producing erratic intensities ranging all the way from the minimum (associated with ZrO_2) up to a maximum. The only apparent cause of the inconsistency is due to a conversion of the $FeZrO_3$ to $Fe_2O_3 + ZrO_2$ during a preliminary low-temperature preheating of the samples in the electrodes prior to striking the arc. The duration of this short-circuit period was not kept constant and, in fact, omitted in cases, but was irregular. At present, however, it seems certain that this minor point in the operating technique has had a tremendous influence on the results. I do not claim, at present, that this can be brought completely under control, as it might happen in an uncontrollable manner after striking the arc. On the other hand, the $FeZrO_3$, if present, in the ignited precipitate, would be expected to be meta-stable and thus tend to segregate ZrO_2 as a result of slight thermodynamic changes. This is a common mineralogical feature of ilmenite deposited from silicate magmas, as TiO_2 nearly always segregates from $FeTiO_3 \cdot Fe_2O_3$ in nature. Perhaps a slight preheating tends to segregate ZrO_2 to a greater or less degree from the precipitated mixture (plus carbon) prior to arcing. In the initial ignition of the precipitate to the oxide, any segregate oxides must have recombined on further heating. It seems, therefore, that the presence of carbon influences this preheating reaction.

Further experiments[5] on this problem are under way, but the above results will surely point out one type of limitation which may be expected in spectrochemical methods. In conclusion, I want to say that this is the most troublesome example I have ever encountered.

The author wishes to acknowledge the technical assistance of Mr. Sam Drexler with whom the detailed data will be published (*9*) jointly.

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(*b*) H. Kaiser, "Contribution to Quantitative Spectrum Analysis Especially of Light Metals," *Metallwirtschaft*, Vol. 16, pp. 1095–1101 (1937).

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[5] Added since presentation of paper: It has been found that preheating decreases the Zr-line intensity by a factor 3, and that a slight preheat for a few seconds at a temperature below 100 C. will produce half of this decrease. In addition, a vigorous preheat does not lower the Zr-line intensity in spectra of the precipitated mixture below those obtained from mechanical $Fe_2O_3 + ZrO_2$ mixtures.

Remarks on Precision and Reproducibility in Spectrochemical Analyses

By O. S. Duffendack[1]

All methods of spectrochemical analyses depend upon a calibration procedure that rests upon measurements on spectra of prepared samples of the materials to be analyzed or of samples that have been analyzed by chemical methods. Only in case a series of samples has been made from such materials that one can be sure of the absolute amounts of the test elements in the sample can a test be made as to the absolute accuracy of analyses by spectrographic methods. Few such cases have been reported, and so not much can be said with certainty about absolute accuracy. Indeed, few such cases can be expected because the struggle for materials for the preparation of such samples out of substances known to contain not more than the merest traces of impurities is still going on, and to date only a relatively few such substances are obtainable among the metallic elements and compounds. At the 1936 meeting of the Society, Duffendack and Thomson reported two series of tests,[2] a series of 97 analyses for sodium, and a series of 76 analyses for potassium, on materials that approach the desired purity. The distribution of errors in these analyses follows, in general, the expected random distribution and the amounts of the errors correspond to those claimed for the best techniques of spectrochemical analyses. There is a growing confidence in the present-day techniques among those using them that the absolute errors in spectrochemical analyses, in the more favorable cases where interference from extraneous elements of varying abundance is negligible and where the best types of analytical spectroscopic sources are applicable, are, in the range of abundance of the test element from about 0.001 per cent to, say, 5 per cent, on the average within 5 per cent of the amount of the element present and that an error of more than 10 per cent under such circumstances will very rarely occur.

The reproducibility of results from spectrochemical procedures is readily subject to test and has been tested many times. Specific examples of such tests readily come to mind, as, for example, tests reported by Vincent and Sawyer[3] where repeat analyses of the same specimens of cast iron alloy for silicon show a maximum deviation of less than 3 per cent. Other cases of this order of reproducibility are known for the more favorable analytical materials. In general, for all kinds of materials, the maximum "spread" in the results from repeat analyses seldom exceeds 25 per cent except in cases of trace analyses where the abundance of the test element is of the order of 1 ppm. or less. In these cases, the "spread" may be 100 per cent or more of the amount of the element present.

The "probable" errors in the results of spectrochemical analyses have likewise been frequently computed. The results here are in keeping with those on reproducibility as cited above as they should be. One case from the alkali industry, in which nearly every large producer of caustic liquor has installed spectrographic equipment, has come to my attention and will be of interest. The results are from the spectrographic laboratory of one of the large producers of caustic liquor. It must be kept in mind that this is a case of trace analysis as the abundance of the test elements indicate. The data at hand are for 36 separate determinations of the elements present in the same sample of caustic liquor. The following figures give the abundance of the element and the "probable error": copper 0.000007 ± 0.000002 per cent, silicon (as SiO_2) 0.0040 ± 0.0002 per cent, magnesium (as MgO) 0.00017 ± 0.00001 per cent, manganese 0.000010 ± 0.000001 per cent. Such data as these and the spread of the use of spectrographic technique in this industry are typical and show that the results of spectrochemical analyses are good enough for the requirements of the industry. The continued spread of the use of spectrographic methods among various industries reflects the same conclusion for industry in general. The principal problem is not one of increasing the degree of reproducibility but in increasing the sensitivity of spectrographic methods. The development of processes that are now producing materials of high purity in the alkali industry makes it necessary to find new analytical procedures that are capable of measuring traces of impurities of extremely small amounts, and this same development is going on in other industries. One can say for spectrochemical analysis that its success in trace analysis has been a contributing factor in the development of methods of producing materials of higher purity.

Comparisons of the results of spectrochemical analyses with those of chemical analyses of the same materials are well known. In cases where good reproducibility can be expected with both methods, the checks are as close as the reproducibility would lead one to expect as, for example, in the case of silicon in cast iron alloy in the report cited above. In other cases the checks will not be so good and one method or the other will be favored depending upon which has the higher reproducibility. Such a check is reported by Duffendack and Wolfe.[4] Spectrochemical and chemical methods check and supplement each other. Both are necessary and each has its peculiar advantages and disadvantages.

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[2] O. S. Duffendack, "Developments in the Quantitative Analysis of Solutions by Spectroscopic Means," *Proceedings*, Am. Soc. Testing Mats., Vol. 36, Part II, p. 301 (1936).

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Variations in Spectral Response of Spectographic Plates*

By J. T. Mireles Malpica,[1] G. J. Steele,[2] and B. J. Mulvey[3]

In quantitative spectrographic analysis the photographic plate plays two important roles: first, as an intermediate "instrument" in the measurement of the energy associated with the spectrum lines; second, as a permanent record of the measurement.

Quite often little attention is paid to the complex photochemical processes responsible for the final record, with the expectation that the photographic plates will always behave in the same way.

However, this is not the case. Fortunately the characteristics of photographic plates under conditions approximating spectrographic practice have been investigated by many workers.

In order to simplify the presentation of plate characteristics it was decided to perform a series of experiments under definite reproducible experimental conditions, expressing the results in relative terms rather than in energy and optical units which would be of more interest to the physicist than the spectrographer.

Specification of Experimental Conditions:

A General Electric projection lamp (C-8 T-10) concentrated filament, rated at 6 v., 18 amp., was modified by attaching a fused quartz window by means of a graded seal and filled with nitrogen to a pressure of 60 cm. of mercury.

If the lamp is run at a current well below its rated current, the change in the current-temperature function is negligible for limited use. This affords a standard source of continuous radiation as low as 2800 Å, suitable for spectrographic tests in the near ultraviolet.

The high energy per unit wavelength together with the high sensitivity of ordinary color blind plates in the 5000 Å region made it necessary to use a yellow cellophane filter with an absorption region in that neighborhood, giving a more satisfactory density distribution.

Unfortunately this is not a standard filter but it was found readily obtainable commercially. To facilitate comparison with data taken with a different filter, a spectral transmission curve of the filter used is given here. This transmission curve was obtained spectrographically (Fig. 1).

Since the dispersion of the spectrograph has an effect on the density-wavelength distribution, it must be stated that a Zeiss Qu24 spectrograph was used in our tests. The instrument was fixed at an aperture of $f/15$ and a slit width of 0.1 mm.

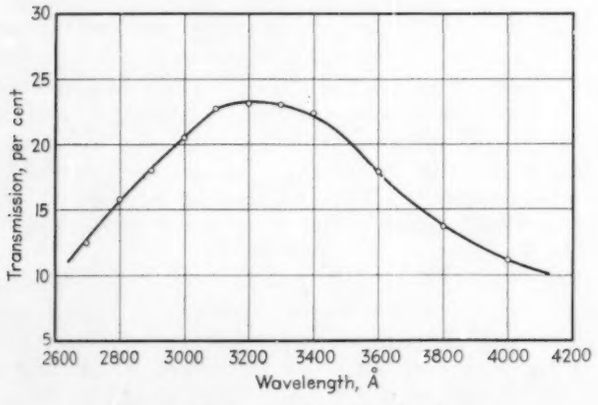

Fig. 1.—Transmission of Cellophane.
Used with Tungsten lamp for the study of spectral response.

TABLE I.—TEST RESULTS.

Plates No. 1:

PLATE 1A

Wavelength, Å	Top Intensity	Bottom Intensity
2900	1.95	1.9
3000	3.0	3.4
3100	6.8	7.0
3200	12.5	12.5
3300	21.3	21.7
3400	32.5	33.7
3500	53.0	56.0
3600	98.0	98.0

PLATE 1B

2900	2.1	2.0
3000	4.2	4.6
3100	7.8	8.1
3200	12.5	12.5
3300	21.3	22.0
3400	32.5	32.3
3500	46.0	46.8
3600	70.0	70.0

Plates No. 2:

PLATE 2A

2900	1.6	1.75
3000	2.7	3.15
3100	6.2	7.0
3200	12.5	12.5
3300	21.3	20.7
3400	36.1	36.2
3500	88.0	74.0
3600	100	100

PLATE 2B

2900	2.0	1.9
3000	3.2	3.4
3100	7.4	7.0
3200	12.5	12.5
3300	21.2	20.6
3400	33.0	34.0
3500	50.0	50.0
3600	82.0	83.0

Plates No. 3:

PLATE 3A

2800	1.0	1.1
2900	1.65	2.1
3000	3.4	3.5
3100	7.2	6.6
3200	12.5	12.5
3300	20.0	22.3
3400	32.0	31.0
3500	48.0	46.5
3600	63.5	64.0

* In a paper by J. T. Mireles Malpica on "Quantitative Spectrographic Analysis," there is described a method of quantitative spectrographic analysis which eliminated errors due to spectral response variations. This appeared in the *General Electric Review*, Vol. 43, No. 7, July, 1940, pp. 288–297; No. 8, August, 1940, pp. 333–335.

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[3] Spectroscopist, General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

PLATE 3B

2800	0.97	1.0
2900	1.5	1.85
3000	3.7	3.4
3100	6.9	6.6
3200	12.5	12.5
3300	21.0	21.5
3400	32.0	31.7
3500	47.0	46.0
3600	63.0	69.0

Plates No. 4:

PLATE 4A

2900	2.1	2.5
3000	3.7	4.3
3100	6.9	7.2
3200	12.5	12.5
3300	18.7	19.3
3400	25.0	26.0
3500	36.0	34.0
3600	48.0	46.0

PLATE 4B

2900	3.4	3.0
3000	4.3	4.3
3100	5.5	5.0
3200	12.5	12.5
3300	19.3	19.2
3400	24.7	26.0
3500	38.5	36.5
3600	51.0	50.0

Plates No. 5:

PLATE 5A

2900	2.9	2.9
3000	3.8	3.8
3100	6.3	6.2
3200	12.5	12.5
3300	20.6	19.0
3400	26.8	25.7
3500	36.0	36.5
3600	45.0	48.0

PLATE 5B

2900	2.9	3.0
3000	3.5	3.5
3100	6.3	6.3
3200	12.5	12.5
3300	19.3	19.0
3400	27.0	26.6
3500	38.0	36.7
3600	48.0	49.7

Plates No. 6:

PLATE 6A

2800	1.0	1.0
2900	1.5	1.5
3000	3.7	3.1
3100	7.6	7.6
3200	12.5	12.5
3300	21.6	21.5
3400	38.0	35.5
3500	56.0	54.0
3600	71.0	69.0

PLATE 6B

2800	1.5	1.5
2900	2.7	2.7
3000	4.4	4.1
3100	7.1	7.2
3200	12.5	12.5
3300	20.8	20.8
3400	31.5	31.8
3500	45.0	45.2
3600	55.0	55.0

CONDENSED COMPARISON OF DATA.

Plate	Uniformity Index, per cent	Reproducibility, per cent
1A	1.11	9.7
1B	0.35	
2A	3.0	12
2B	0.4	
3A	0.1	0.6
3B	1.6	
4A	1.0	2.3
4B	0.7	
5A	0.3	1.2
5B	0.1	
6A	1.8	9.2
6B	1.6	

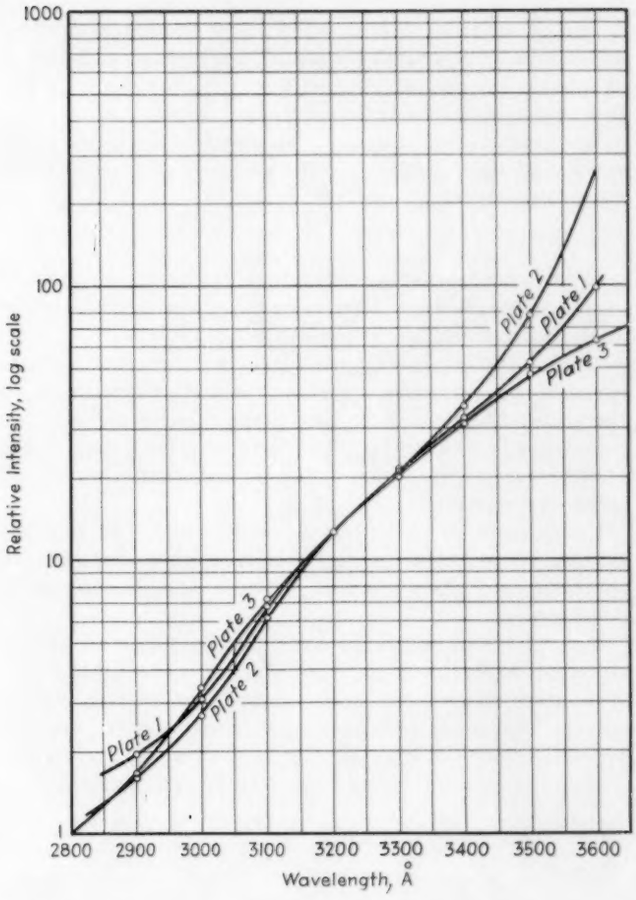

Fig. 2.—Relative Spectral Response of Photographic Plates.
G. E. lamp C-8 T-10, Quartz window, 16 amp. 1 min. exposure.

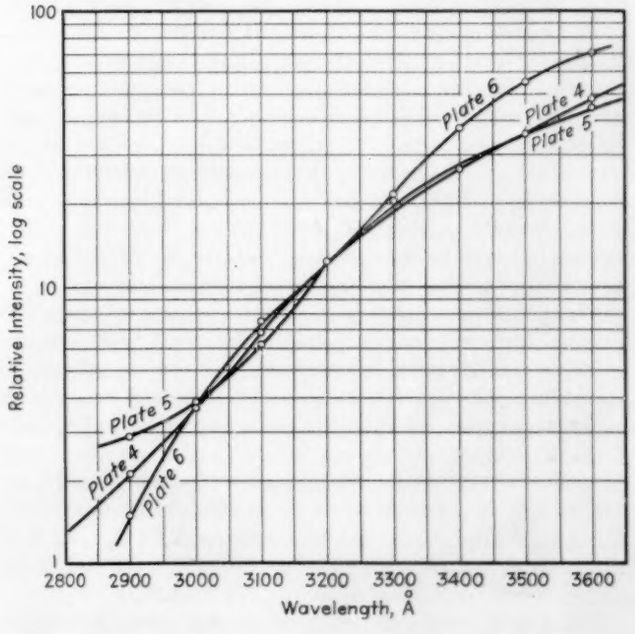

Fig. 3.—Relative Spectral Response of Photographic Plates.
G. E. lamp C-8 T-10, Quartz window, 16 amp. 1 min. exposure.

The plates were developed in *D-76* developer at 18 C. for 20 min. in a developing machine which is described in an article by one of the authors which appears in the July, 1940, issue of the *General Electric Review*.

We believe that these data, together with the data given with each test, will suffice to establish a comparison with future work.

Procedure:

Using a seven-step logarithmic sector disk, two spectrograms of the tungsten lamp were taken on each plate, one at the bottom and one at the top of the plate.

At a suitable wavelength (3200 Å) the characteristic curve of the spectrogram was determined by measuring all the steps. Against this characteristic curve the relative intensities (exposures) of the fourth step were determined at different wavelengths; that is, the internal standard technique was used.

Comparison of the relative intensities of the top and bottom spectrogram on each plate serves as an index to the combined plate spectral response and uniformity of development.

Two plates of each kind were used to obtain an idea of the reproducibility from plate to plate. (See Table I.)

In order to obtain a ready comparison of the relative spectral response, the relative intensities from 3300 to 3600 Å, inclusive, were averaged. The upper region was chosen because the normalizing scheme makes the intensities for 3200 Å 12.5 for all spectrograms. Above and below this point, variations in spectral response appear as variations in intensity values.

Half the difference in average intensity between the top and bottom spectrograms, expressed in per cent, is considered an index of plate uniformity.

Half the difference between the averages of two plates of the same type, also expressed in per cent, is considered a reproducibility index from plate to plate.

Conclusions:

In order to draw authoritative conclusions it would have been necessary to test a great number of each type of plate, preferably from different emulsion batches. However, these limited tests give a general idea of the characteristics of these plates in the near ultraviolet, and afford a means of selecting a type of plate with promising characteristics for further study.

(*a*) Inspection of the data shows that all the plates tested have in general the same type of spectral response, as shown graphically in Figs. 2 and 3.

(*b*) In general variations from top to bottom in the same plate are slight.

(*c*) In some plates the variation in spectral response from plate to plate of the same type is large and is a possible cause of serious error in quantitative work if assumed uniform. However, plates Nos. 3, 4, and 5 showed good uniformity from plate to plate.

DISCUSSION

Mr. William H. Bassett, Jr.[1]—I have been asked to discuss this subject from the viewpoint of Committee B-1 on Copper and Copper-Alloy Wires for Electrical Conductors. It is interesting to note that the predecessor of Committee B-1, Committee W, was the oldest A.S.T.M. non-ferrous committee and that one of its members made the initial use of the spectrograph in this country for the study of copper and non-ferrous materials.

The universal method of controlling the quality of electrical conductors is to make a battery assay and a resistance or conductivity determination. The assay gives useful information about the copper and lead content of the metal and a satisfactory resistance measurement indicates that certain impurities are within desired limits. If an unsatisfactory resistance measurement is obtained, a spectrographic analysis is expected to show the offending impurity such as iron, nickel, silicon, arsenic, etc.

Manufacturing difficulties may be caused by some impurity that does not seriously affect the conductivity. Here again the spectrographic analysis is of assistance to the investigator of the production problems. The amounts of the impurities in electrical conductors are usually small. The spectrographer is expected to state whether such metals as silver, arsenic, antimony, tellurium, and nickel are present in amounts less than fifteen parts per million. For lead, tin, silicon, and iron, amounts in the order of fifty parts per million are of interest. The amount drops to five parts per million in the case of bismuth.

The spectrograph, as indicated above, is a tool which is used to assist the chemist in quickly finding the cause of resistance failures or manufacturing difficulties, or can be used to advantage in the research work connected with the development of new electrical conductors.

Mr. T. S. Fuller.[2]—There can be no question concerning the usefulness of the spectrograph and its application to control problems relating to metals and various alloys in industry. In many cases, as, for instance, with zinc-base die casting alloys, babbitts, and many other compositions, the Go-no-Go methods are satisfactory.

The experience gained from the control of impurities in the zinc-base die casting alloys by means of the spectrograph may perhaps be regarded as having provided a foundation for quantitative determinations by that method. Certainly a comparison as to accuracy and cost of the methods of spectrography with the older wet methods is extremely favorable to the former.

As pointed out by Mr. Wright,[3] those interested in spectrography have come to classify analyses made by the method according to three groups: (1) qualitative analyses; (2) Go-no-Go analyses; and (3) quantitative analyses.

The term "semiquantitative" is indefinite and, for that reason, may be regarded by many as undesirable. It has been the experience of our laboratory on many occasions that after having complied with a request to determine

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[3] Thomas A. Wright, "Variables *versus* Constants in Emission Spectrography," *Proceedings*, Am. Soc. Testing Mats., Vol. 40, p. 1355 (1940).

"semiquantitatively" the constituent of a sample by means of the spectrograph, we are requested to make a good guess concerning the amounts of the elements present. Guessing in spectrography after many years of experience with a wide variety of materials has proven to be unwise, the reason, of course, being that the spectra of the elements vary from weak to strong, thus making a "good guess" impossible.

As pointed out by Mr. Wright, the successful spectrographer necessarily associates a good deal of art with his science, with the result that complications are numerous. For the best results, therefore, engineers must work as closely as possible with the spectrographer in order that he may fully understand the principles of phraseology and the limitations of the science.

Whether we like it or not when considering chemical analyses, accuracy comes before cost. When a method offers both lower costs and greater accuracy, as is many times the case when a spectrograph is used, a tool of great value is available. Once the apparatus and method are standardized, the story which is produced on a silver negative is a scientific achievement of great merit.

In every chemical method there exists a question of percentage tolerances which must necessarily be determined by the accuracy of the method. Separate tolerances must of course be indicated for each of the determinations made by spectrograph and may run as high as 10 per cent in case of pig lead, while in the determination of impurities in steel such tolerances may be of the order of 5 per cent.

Then, again, there is the question of sampling which is of prime importance in the satisfactory functioning of any analyses whether made by spectrograph or otherwise.

Many alloys are prone to segregation, and it is quite possible that in such cases special methods of sampling should be applied.

MR. SAM TOUR.[1]—The task delegated to me by Mr. Wright when organizing this symposium was to set forth what the engineers and the metallurgists expect of the spectrographer.

There has been considerable discussion about interpretation of results. The discussion has been from the standpoint of how the spectrographer may interpret his plates. After the spectrographer is through with his little problem of interpretation of what is on the plate and reports his results to the metallurgist or the engineer, the real job of interpretation begins.

I shall direct my remarks toward what the spectrographer should or should not do in reporting his results. We may all appreciate the difficulties the spectrographer has. That is his problem. The metallurgist has his troubles, too. He asks the spectrographer to give some reasonably reliable figures in order that he may apply them to his own problems. The metallurgist does not want to be burdened with solving the spectrographer's problems. If the spectrographer cannot put something on a sheet of paper that is of some value, interest, and is usable to the engineer and metallurgist, he should so state, in his report, so that the metallurgist may stop short and not attempt to apply the so-called "good guesses" that may not be good guesses at all.

I would like to point out a few of the terms that the spectrographer should not use in reporting results to the metallurgist or the engineer, unless each of the terms is specifically and clearly defined. Mr. Koch gave specific definitions for some of the terms he uses. Without specific understandable definitions, the spectrographer should not report an element as "major"; he should not report it as "minor"; he should not say "plus"; he should not say "present"; he should not say "trace"; he should not say "spectrographic trace"; he should not say "not found"; and he should not say "not found on so many grams." Unless the metallurgist happens to be a spectrographer as well, he does not know, when a spectrographer says "not found," whether the element was looked for and not found, or whether the technique employed was such as not to reveal the element even if present. The average metallurgist has no way of knowing the meaning of these terms unless given a handbook of instructions with which to interpret the report.

The spectrographer should report what he feels confident is a fair result of his work. If he is not confident that he has a fair result, he should so state. "Over 50 per cent" or "over 10 per cent" or "between 1 per cent and 10 per cent" are intelligible figures understandable by metallurgists. The term "minor" has no definite meaning. An element may appear "minor" to the spectrographer and be of vital and major importance to the metallurgist. If the spectrographer should give some figures, 0.001 to 0.01 per cent for example, he should be certain that the methods he used warrant such figures. He should not expect the metallurgist to know that the figures are not even good guesses. Even as a chemist should not report to the fourth decimal place when his determination cannot be accurate beyond the second decimal place, so also the spectrographer should not report beyond the limits of accuracy.

If the spectrographer finds something wrong with a sample given him for analysis, if there is evidence of nonuniformity, for example, he should so state on his report. Such things are of interest to the metallurgist or the engineer. Lacking such a notation on the report, the spectrographer should never resort to "But your sample was not uniform," as an explanation for his reported results.

We have two stages of interpretation. First, the spectrographer interprets his technique and his results. Second, the metallurgist or engineer must interpret the report from the spectrographer and apply it in practice. The latter must know whether he is applying something that is fairly definite or entirely indefinite and based upon wishful thinking as to accuracy, sensitivity, and reproducibility. The metallurgist or the engineer should not be expected to solve the problems of the spectrographer in order to solve his own metallurgical problems.

MR. W. H. FINKELDEY.[2]—I would like to state at the outset of my discussion that my experience with spectrographic analyses has not been as a spectroscopist but as an engineer using the results of spectrographic analyses.

There has been considerable testimony in the papers this morning to indicate that the accuracy of spectrographic analyses is ±10 per cent. In evaluating the re-

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[2] Member of Firm, Singmaster & Breyer, New York, N. Y.

sults of the analyses which we have had done for us, I am inclined to believe that the accuracy is ±10 per cent if you are not interested in significant figures beyond the second decimal place. If, however, the elements you are analyzing for are present in the third decimal place, I do not believe an accuracy of ±10 per cent holds true.

Before citing an example to illustrate this point, I should like to explain that most of the spectrographic analyses we have had made for us have been done by commercial testing laboratories or college professors operating spectrographs in their laboratories on the same basis as commercial testing laboratories.

In a particular case we were interested in determining the percentage of magnesium present in ordinary commercial slab zinc which we had been regularly receiving from one source of supply for several years. Over a period of time the analyses ran between 0.001 and 0.002 per cent and on one occasion 0.0005 per cent. We had occasion to submit to another spectroscopist a sample of the same spelter and were surprised to receive a report stating that the magnesium content was 0.000005 per cent. While it is true that the determinations were not all made on the same sample, it seems unlikely that where one spectroscopist had been reporting magnesium contents of 0.001 to 0.002 per cent on many samples of spelter all from one source, the magnesium content would suddenly change to 0.000005 per cent on a sample of spelter from the same source when the analysis was made by another spectroscopist. To obtain further information on this point we took a sample of drillings from a slab of high purity spelter, and after thorough mixing, sent part of the sample to a commercial testing laboratory, who reported 0.002 per cent magnesium. A second part of the same sample submitted for a check analysis to the same laboratory at a later date produced a report of 0.001 per cent magnesium, and a third portion of the same sample sent to another spectrographic laboratory produced a report of no magnesium present.

As a further example of the difficulty of securing an accuracy of plus or minus 10 per cent in the third decimal place, I give below the results of two analyses of a zinc alloy by the same spectrographic laboratory on the same sample of drillings submitted at two different times approximately six months apart:

Cadmium, per cent	Lead, per cent	Iron, per cent	Magnesium, per cent	Aluminum, per cent
0.001	0.004	0.005	0.001	0.23
0.08	0.001	0.003	0.001	0.22

You can see from the foregoing that an accuracy of ±10 per cent was secured on the element aluminum, where the significant figures went as far as the second decimal place, but with the exception of magnesium the same accuracy was not secured on those elements present in the third decimal place.

It would appear from all this that not only is it difficult to secure a ±10 per cent accuracy in the third decimal place in the same laboratory, but it becomes even more difficult to secure reasonable checks between two different spectroscopists on the same sample if you are interested in elements in the third decimal place.

There is a point here which I think is worth considering. Spectrographic analyses are often made for engineers and others who are not acquainted with what is involved in making a spectrographic determination. They are not in a position to understand, as Mr. Tour has pointed out in his remarks, just what is involved in a spectrographic laboratory to get the results that they are interested in. They have the impression, which of course is a misconception, that because a spectrograph can determine elements in the fourth and fifth decimal places, the method used must necessarily be a very accurate one without realizing that there is a high personal and procedure factor which should be considered before evaluating any result obtained by spectrochemical methods. Neither do they understand fully how it can be possible for two different spectroscopists, using possibly two different methods for preparing the sample and handling the same in the spectrograph, to get significantly different results on the same sample, although each spectroscopist can check his own figures on repeated analyses. Therefore, the spectroscopist should make clear, when dealing with lay minds, just what can be accomplished with spectrographic methods in any particular case and state what the probable accuracy will be.

The old story of securing a representative sample for analysis is another point worth considering. For example, if it is desired to determine the amounts of the common impurities in a carload of spelter using spectrographic analytical methods, the usual practice of obtaining a sample would be to drill ten or twenty slabs selected at random from the car, each slab drilled diagonally in three places, the drillings from all ten or twenty slabs mixed thoroughly together, coned and quartered to finally secure about an eight-ounce sample for submission to the laboratory. We might question at this point how accurately such a sample represents the carload of spelter, but the question mark in our minds is magnified many times when we consider how small is the amount of material selected from this sample that actually gets into the crater of the electrodes of the spectrograph. The question of whether this tiny bit of material can accurately represent the carload of spelter is certainly worth considering.

The problem of securing a representative sample of a large lot of material is well known to all and probably is not the concern of the spectroscopist. However, his analytical methods should accurately "sample" the sample.

I have no doubt that the standardization of spectrographic technique and procedure methods now under active consideration by Committee E-2 will do much to improve the accuracy of spectrographic analytical methods.

MESSRS. M. F. HASLER[1] and H. W. DIETERT.[2]—The accuracy of quantitative spectrochemical determination of various elements may be increased by proper selection of electrodes. An investigation has revealed certain inherent advantages of different types of electrodes. Three distinct types of electrodes will be described.

The three types of electrodes may be classified as follows: (1) the boiler type, (2) the bombardment type, and (3) the high streaming velocity type. Each one emphasizes and exaggerates one of the basic phenomena of discharges.

The "boiler type," Fig. 1, relies almost entirely on the heating properties of a discharge to vaporize the sample

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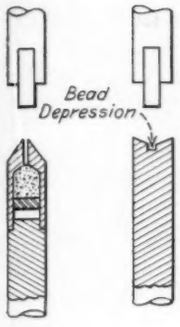

Fig. 1.

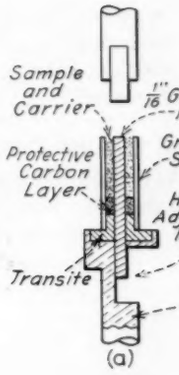

Fig. 2.

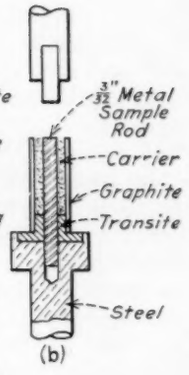

Fig. 3.

out of the boiler and into the arc. Because it confines the sample it is ideal for those that tend to decompose too violently and blow out of open arcs. Its chief limitations are related to the fact that the boiler temperature cannot be made high enough to readily vaporize refractory oxides. Thus its field of application is limited to the lower boiling point metals and oxides that can be readily vaporized at the temperatures obtainable. Typical examples are the determination of lead in blood by placing carbonized blood into electrodes, the determination of zinc in hair by an analogous procedure, lead and cadmium in zinc oxide, the alkalies in salt samples, and so on. By the use of suitable internal standards, results within ±10 per cent of the true quantity can be obtained for these volatile elements.

The "bombardment type," Fig. 2, or flat electrode depends largely on two factors for its success. First, it employs the direct bombardment of sample by the electrons of the arc, and, second, it readily allows multiple arcings which can be used to average out fluctuations. For its most successful operation a small sample spread over the arcing surface is completely vaporized. To prevent loss of the bead, often formed toward the end of the arcing, a depression is drilled at the center of the electrode. The arcing cycle is repeated a number of times, say six, to produce a single spectrogram. Because it is essential that a rather thin layer of sample be used, this limits its use to powders, or concentrated solutions which may be dried on the electrode's end. For powders 12 mg. are weighed out. This sample is divided into six approximately equal proportions by estimation, and each one of these is arced in turn at an appropriate current to produce a single spectrogram. A suitable value for the current is 7.5 amp. though values between 5 and 10 amp. have been employed for various types of samples. For success in refractory element analysis it is essential that the sample be burned to completion each time. This usually burns the electrodes away so rapidly that new ones must be used after each three fillings. This consumption of electrode material also introduces the main limitation to this method of arcing, namely, low sensitivity on low boiling point metals. These elements are vaporized very rapidly at the beginning of the arcing cycle and do not contribute much to the total discharge which includes considerable carbon evaporation. Since this last produces considerable background the total exposure must be kept quite low.

The direct bombardment of the sample by electrons has a very important effect, namely, the decomposition of molecules as well as their evaporation. If complete decomposition of all compounds could occur before entering the portion of the arc photographed, many effects due to the different rates of evaporation of different compounds of the same element could be avoided. The reason that this is so important is that for much analytical work it is necessary to be able to prepare synthetic standards duplicating the percentages of the positive elements under test but not necessarily the negative radicals or the exact physical form of the sample. Quantitative mineral work in particular demands this as it is often necessary to use a synthetic oxide mixture as a standard. As an additional aid to thermal decomposition and as a dilutent nine parts of sodium carbonate can be added to one of sample or synthetic standard. This produces an alkali fusion on the flat electrode. Addition of ground carbon to the sample also aids certain refractory element analyses. In general the analytical accuracy obtainable with these electrodes is better than the boiler electrodes. Also it is less dependent on the particular physical properties of the element under test and the internal standard. This makes these electrodes much more generally applicable than the boiler electrodes. For favorable cases determinations can be made to ±5 per cent.

The "high streaming velocity type," Fig. 3 (*a*), of electrode combines the properties of the other types but relies for its action on the reaction of a carrier medium. The electrode is filled with equal quantities of sample and carrier, that are ground together. Upon striking the arc the carrier produces a large volume of gas which causes the particles of sample ground with it to be blown into the arc. Thus the normal streaming action present in all discharges is greatly amplified. With a suitable carrier, from 50 to 75 mg. of a sample may be blown through the arc in 5 to 10 sec. The particles in their flight through the arc are bombarded by electrons and gas atoms so that vaporization and decomposition occur simultaneously.

In actual practice a number of carriers have proved usable. They include ammonium salts, carbon, metal carbonates, and various mixtures of these. Most work has been done employing ammonium chloride or carbon, the latter produced by carbonizing c.p. sucrose and then grinding it to 200 mesh. One important precaution is to have both the sample and the carrier medium thoroughly dried as moisture content acts as an additional carrier.

Actual practice utilizes 50 to 75 mg. of sample and an equal amount of carrier for a single filling of the electrode. To protect the transite insulator shown in the figure, a layer of carbon produced by filing carbon electrode rods is utilized and put in place before the sample is introduced. Currents from 7 to 10 amp. are suitable, much work having been done at 8 amp. Before introducing the sample, a few seconds prearcing of the electrodes permits adjustment of the current. A 5-sec. arcing of the sample suffices to evaporate about three-quarters of it. It is important not to arc to completion as the character of the arc changes markedly at this point. The intensity of this arc is from 5 to 10 times as high as an ordinary arc so that one 5-sec. arcing suffices for an exposure. In case it is desirable to use multiple arcings, the graphite shell may be refilled with the sample-carrier mixture directly over the remainder and rearced for several other 5-sec. periods.

Here the lower $^1/_{16}$ electrode is moved up to the level of the outer cup before each arcing. A special steel holder facilitates this adjustment.

This type of arc has a number of very desirable properties. First, the arc is carried almost entirely by the sample so that the usual carbon-band background is much suppressed, giving very high sensitivities in general. Second, the fact that a large sample is used eliminates sampling errors. This is particularly important for ore testing work. Third, each particle that passes through the arc goes through its vaporization cycle individually and thus the whole arc does not change its character during the arcing time—in other words, does not fractionally distill. This makes for good reproducibility and simplifies the interpretation of arcing phenomena. However, this advantage is also a limitation, as samples possessing large quantities of elements with low excitation potentials cannot be analyzed for small traces of elements with high excitation potentials. The presence of alkalis, for instance, will limit the sensitivity of silicon, phosphorus, etc. However, this effect can often be overcome by adding quantities of elements with a high excitation potential, for example, phosphorus to enhance silicon, etc. This case is entirely different from the flat electrode one, which is so sensitive for certain refractory determinations because it first vaporizes all the volatile components such as the alkalies that tend to reduce sensitivity, and then vaporizes these refractories later in the cycle. In the last stages of arcing in particular, it becomes a carbon arc with impurities. On the other hand, the high streaming velocity type of arc is much less like a carbon arc and much more like a true sample arc. Continued study of it should explain many fine points of arcing technique.

The second modification of the high-streaming velocity arc allows direct arcing of metal pegs in such a manner that high sensitivity and reproducibility is obtained. This allows direct rapid analysis of material which previously required acid treatment and arcing of salts or solutions to obtain adequate sensitivity. It has been applied successfully to the analysis of minor constituents in die-casting alloys, bronzes, aluminum, steel, and cast iron.

A typical example is die casting analysis. A rod of the sample $^3/_{32}$ in. in diameter and $^7/_8$ in. long, is mounted as shown in Fig. 3 (*b*). The carrier medium, ammonium chloride in this case, can be obtained as a c.p. reagent in powder form. It is used directly to fill the space above the transite insulator and between the rod and the graphite sleeve. The arc is operated at 10 amp. for 5 sec. This vaporizes about 90 mg. of the sample. The carbon sleeves employed can be reused after acid washing and thorough drying. The transite insulators can also be used over and over again, making for low material cost per analysis.

The analytical accuracy obtainable with these high-streaming velocity discharges is comparable to the bombardment type, namely, ±5 per cent in most cases. In the case of metal pegs this is achieved with a single arcing, though for powders multiple arcings are usually required.

It is hoped that this résumé of arc sources will stimulate the use of quantitative spectrochemistry in many fields to which it has as yet not been applied. It appears that any sample may be analyzed quantitatively for any metal or rare earth by a suitable arcing procedure. However, this does not imply that the arc source is the most suitable for all work, as in many cases more accurate work can be done more rapidly with the high voltage a.c. arc or spark. However the d.c. arc is certainly the most universally applicable.

MR. HENRY AUGHEY.[3]—I should like to take issue with Mr. Tour somewhat in his recommendation that the spectroscopist get all of the exact figures into the hands of the metallurgist in order that he may make his decision on the basis of complete and quantitative information. Putting exact figures on all concentrations for all elements takes time and money and a great deal of it. When only an occasional sample of a certain type comes along it may be possible for the spectroscopist and the metallurgist to get together. The metallurgist can say, "This sample has something wrong with it and this sample has something good about it; I want to find out what causes that difference." The spectroscopist can then examine these samples and a relatively simple comparative analysis, obtained at little expense and available almost at once, may be as useful as the best quantitative analysis and can be obtained at little expense; that is the reason I wish to emphasize our semiquantitative approach. If a quantitative analysis is required we are glad to do it but we do not recommend it when there is the possibility of obtaining the same information more quickly by simple comparison.

MR. T. A. WRIGHT.[4]—Mr. Finkledey comments on the difficulty of getting a precision of 10 per cent below the second decimal place. Speaking for the moment as an old analytical chemist it is only fair to state that most of that tribe would be glad to get a precision of one or two hundred per cent in the fourth or even third place. The difference between 0.0001 and 0.0002 is not so bad as it sounds for most purposes. On the whole, spectrography meets the requirements much more readily than gravimetric chemical analysis and even at times of colorimetric.

The chemist often hopes the color is that of element *X*. The spectrographer rarely has doubts that the line is that of element *X*. In either event contamination and even segregation have their role in any scheme, but spectrography discloses either more readily and therefore can guard against either more readily.

Again no analysis can be better than the sample and most results are at best no more than the opinion of the one who made it. How valid that opinion is depends on factors such as are being brought out today.

MR. M. L. FULLER.[5]—Several remarks made by Mr. Finkeldey and Mr. Dietert move me to say something about the problem of sampling. Mr. Finkeldey questioned whether the material that we put into the electrode would be a representative sample. I should like to assure him that Committee E-2 is sponsoring a method of spectrographic analysis for this particular substance, zinc, in which a representative sample can be introduced into the electrode. This method, which is also the method upon which my paper was based, is a solution method by which one takes into solution a sample large enough to be repre-

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[4] Technical Director and Secretary, Lucius Pitkin, Inc., New York, N. Y.
[5] Research Division, The New Jersey Zinc Co., Palmerton, Pa.

sentative and then introduces a portion of that into the electrode, thus eliminating the sampling problem.

In presenting his discussion, Mr. Dietert spoke of etching the surface of a zinc alloy die casting and then sparking it in order to excite its spectrum. The etching of a zinc-alloy die casting preferentially removes the more soluble zinc-rich phase leaving behind an aluminum-rich phase concentrated at the surface. I would suggest that the sparking of such a surface might lead to an incorrect result and that it would be better practice to excite the spectrum from an unetched cross-section of the casting.

MR. DIETERT.—In reply to Mr. Fuller's first comment on the size of the sample, I wish to state that from 70 to 90 mg. of the sample are consumed in one exposure. Since the method is fast one can readily make a number of exposures thus obtaining a good representative sample.

Now as to this etching, an acid is used to cause a layer of salt to be formed on the surface of the material under test. This salt layer throws the surface of the material in the spark or arc, thus causing excellent sensitivity.

MR. A. E. RUEHLE[6].—In connection with Mr. Finkeldey's remarks, I think it should be reemphasized that the first responsibility of any analyst is to avoid gross errors. High reproducibility is of no value if the sample taken is not representative of the specimen to be analyzed. The extreme sensitiveness of spectrochemical methods makes it all too easy to employ a nonrepresentative sample. We regard every material as nonuniform until we have evidence to the contrary; hence, we use dried solutions to a much greater extent than self electrodes or globules.

I should like to say a few words about means of expressing reproducibility. The figures in my paper[7] were given in terms of average deviation from the mean, which is a very common way of expressing precision. I have begun to feel, however, that spectrocopists, and perhaps analysts in general, should rather use standard deviation, σ, as the means of expressing precision $\left(\sigma = \sqrt{\frac{\Sigma d^2}{n}}\right)$. The standard deviation gives more weight to the occasional large deviations that seem to be inherent in the method than does the average deviation. For example consider these two sets of data:

	I	II
	0.050	0.053
	0.051	0.046
	0.060	0.045
	0.048	0.047
	0.040	0.054
	0.051	0.055
Average	0.050	0.050
Average Deviation	0.004	0.004
σ	0.006	0.004

The reliability of a single determination is better for the second set than for the first and this is reflected in the standard deviation but not in the average deviation figures.

I want especially to call to the attention of this group the recommendation contained in the 1933 ASTM Manual on Presentation of Data (page 37), and in Supplement A (1935)[8]: "Present as a minimum, the average, the standard deviation, and the number of observations."

[6] Bell Telephone Laboratories, Inc., New York, N. Y.

[7] See p. 33.

[8] Manual issued as a separate publication of the American Society for Testing Materials.

MR. J. S. OWENS.[9]—For the benefit, particularly, of those present who are not familiar with modern spectrochemical techniques, I feel that it should be pointed out that the papers, as presented verbally today, have tended, perhaps, to overemphasize the limitations of spectrochemical methods at the expense of their advantages and proven applications. All experienced spectroscopists realize that these methods, like all other analytical procedures, do possess certain experimental difficulties and limitations. However, the large, and increasing, number of successful applications in varied fields shows that, by the development and use of improved technique, many of the former limitations have been overcome.

It might be well also to bear in mind that, before general criticisms are made of spectrochemical or other analytical methods upon the basis of specific analyses, careful consideration should be given to the actual techniques employed and the training and experience of the personnel.

MR. T. M. HESS.[10]—Our laboratory made a thorough study of photographic emulsions and developers available for use at the time, before we attempted to make any quantitative determinations. A similar study preceded the development of the methods for the analysis of caustic liquor and the analysis of steel.

One of the plates that has been used successfully in our laboratory, as well as in several other laboratories, is the polychrome plate, manufactured by the Eastman Kodak Co. for a considerable number of years. This plate has a relative constant contrast over the wavelength region 2300 to 3600 Å which is a desirable characteristic if one is to use the internal standard method.

MR. P. A. LEICHTLE.[11]—We are indebted to Mr. Stout for a paper which is of considerable interest to spectroscopists in the copper and brass field. It should be emphasized that all of the larger copper and brass companies are using the spectrograph extensively as a "production tool."

In our plant the Spectrographic Section consists of two men, who are required to analyze from 125 to 175 samples per day on a large Littrow model quartz spectrograph. The Spectrographic Section works in close coordination with the Chemical Section in the control of the chemical composition of the casting shop production.

We are using the spectrograph not only for the control of impurities in the high conductivity alloys and in alloys requiring high purity on account of manufacturing difficulties, but also for quantitative analysis of certain alloying elements in amounts less than 0.25 per cent. An example of the latter use is the spectrographic analysis of antimony in antimonial Admiralty condenser tubing.

A $^1/_8$-in. solid electrode for the spectrographic analysis is cut from the ladle sample. The counter electrode is a $^3/_{16}$-in. graphite rod. A d.c. arc method of excitation is used. Density measurements of a line pair of selected antimony line and a selected copper line in each spectrum are obtained with a nonrecording microphotometer. The working curve is obtained by similar measurements on spectra of standard Admiralty alloys containing 0.02, 0.04, 0.08, and 0.13 per cent antimony, respectively. In the

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[10] Spectroscopist, Dow Chemical Co., Midland, Mich.

[11] Spectroscopist, Research Dept., Chase Brass and Copper Co., Waterbury, Conn.

range of 0.04 to 0.06 per cent antimony a reproducibility of ±10 per cent is easily obtained. In any quantitative spectrographic work the importance of the standard samples cannot be over emphasized.

Mr. Bassett's paper is of especial interest to us because we are using the spectrograph in controlling the chemical composition of copper alloys to be used for electrical conductors.

Our standard practice is to run both the chemical assay and the spectrographic analysis of the metal before the billets are released from the casting shop. The spectrographic analysis will usually enable us to predict whether the conductivity of the wrought alloy will be satisfactory.

MR. A. E. RUEHLE.[2]—Is there any explanation of the lower precision on copper than on graphite when caustic is being examined?

MR. W. H. KOCH.[3]—I believe it can be accounted for largely by the requirements of the analysis of the caustic liquor and the amounts of those impurities which are present.

MR. T. R. CUNNINGHAM.[4]—I believe it is definitely known that the ordinary graphite electrodes contain small amounts of copper, calcium, etc. In view of the extremely low percentages of impurities shown, I should like to know whether you found most of these in the electrodes, and, if so, how you determined the blank. Did you saturate the graphite electrode with the strong caustic solution prior to the sparking or arcing?

MR. W. H. KOCH.—The technique is to take a sample of caustic soda in a concentration of about 25 per cent and place it on top of a flat electrode and dry it in an oven, in an atmosphere of carbon dioxide gas, so that what you have essentially on top of the electrode is a layer of sodium carbonate about 1 mm. thick. The conditions under which this is arced do not remove that soda ash from the top of the electrode, and blank electrodes run at the same time without soda ash do not show that particular spectral line at that point.

MR. H. B. VINCENT.[5]—Mr. Ruehle has questioned how the precision of spectrochemical analysis should be reported. From mathematics, we have available a substantial background in statistical methods for the computation from data of the standard deviation which is related through a factor to the probable error of a single observation. I wish to recommend that information on the accuracy or the reproducibility of analytical results be reported in terms of the standard deviation.

MR. JACOB SHERMAN.[6]—The December issue of the Analytical Edition of the *Journal of Industrial and Engineering Chemistry* has a very fine paper by F. W. Power, of Fordham University, on a statistical analysis of the accuracy and precision of certain microchemical analyses. His opinion is that one needs at least 350 to 400 measurements before any opinion can be reached about such statistical matters as probable error, dispersion, criteria for rejection or acceptance, etc.

This is in line with opinions of other workers in similar fields of statistical analysis, for example those of W. A. Shewhart of the Bell Telephone Laboratories.

I still have not seen any report of an analysis of, say, 1000 spectrographic determinations which would show that spectrographic error is really a logarithmic function of the amount measured. Estimates and approximations of the error function made from analysis of the results based on 8 to 10 plates are, in my opinion, only intuitive personal judgments on the part of the spectrographer. The various and conflicting estimates of that error function would rather indicate to me a lack of any such simple correlation.

MR. L. W. STROCK.[7]—I should like to make a few remarks concerning the determination of minute amounts of an element, where, of necessity, one is utilizing spectral lines only faintly visible above the spectrum background or emulsion threshold. This is not intended to answer the question whether or not the extremely low concentrations of metals determined in alkali liquors by Duffendack represent real values, but to emphasize the precautions necessary in such cases.

For this purpose please recall the curve of Fig. 1 in my paper. The low-concentration end of this curve flattened off and became parallel with the concentration axis at a $\Delta \log T$ value representing the intensity ratio of the spectrum background to the intensity standard. For simplicity let us say that the curve cannot be extended below the intensity of the background, just as if the black region at the foot of the curve in my Fig. 1 were a solid floor. The practical difficulty lies in the fact that the height of this "floor" usually varies somewhat from spectrum to spectrum and plate to plate, and small variations in its height produce very serious changes in the concentration—intensity relationship on the flat curve in this region.

Let us consider a very specific example in which the curve of my Fig. 1 was obtained from synthetic standards and the background indicated originated by a combination of causes—for example, broadening of the Na-line at 3306 Å, by carbon arc after sample was consumed, and perhaps some emulsion fog. In subsequent spectra, suppose the background in this region is lower, which is easily possible, and occurs even in the most careful work. This lowering of the solid "floor" shifts the curved foot of the real working curve, applicable to this particular spectrum, to lower concentrations and $\Delta \log T$ values. A given intensity ratio value obtained by photometric measurements of this spectrum will lead to a concentration much lower than its actual value when read from the standard working curve constructed for this purpose. As an illustration, I once diluted the Ag in a silicate base containing 0.002 per cent Ag to half, and found 0.00002 per cent Ag in the diluted mixture instead of 0.001 per cent. This discrepancy, amounting to a factor 50, was caused by a relatively small decrease in background as a result of the simultaneous dilution of iron in the sample.

The flattening off of the working curve at low concentrations is also caused by the presence of a detectable

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[5] Research Physicist, Department of Engineering Research, University of Michigan, Ann Arbor, Mich.

[6] Technical Laboratory, Philadelphia Navy Yard, Philadelphia, Pa.

[7] Research Radiographer, New York State Research Institute of the Saratoga Spa, Saratoga Springs, N. Y.

amount of the addition element in the base substance, used for a series of standards. If the flattened portion of a curve involving such a base substance is used as a routine working curve for subsequent analyses, the analytical results will be incorrect and too low, the reason being that at a given concentration in the standard mixture series, the addition element line has an excess intensity due to the residual concentration of that element in the base used. The correct value in this case may be obtained by using the extrapolated linear portion of the working curve, if one is satisfied that no appreciable background is present.

The important fact I want to emphasize is that the numerical value of an intensity ratio is limited by the spectrum background and by the intensity of the line of an addition element already present in the mixture base or solvents, or as an electrode contamination. In all such cases an analytical working curve must become horizontal. Each spectrochemical analyst must decide for himself whether, and in what manner, these factors enter into his technique. Those questioning Duffendack's report on the minute concentrations of metals in alkali liquors should bear in mind these fundamental limitations which frequently lead to erroneous results when faint lines are used.

MR. W. H. KOCH.—I realize that the representation of these figures as given, with the little discussion and little background that has gone with them, is probably inadequate, but this work has been going on for about a year and a half, and not only going on at our laboratory but going on at one of our other plant laboratories, which has a different type spectrograph and different conditions, and also in another laboratory that works entirely by chemical means. They were obtained on synthetic samples but the results were also obtained on natural samples. It is quite possible to make an analysis within that accuracy chemically, as far as manganese and copper and several of the other elements are concerned; so I think we feel somewhat justified in saying that the results we obtained are within the limits that those inadequately expressed figures show.

MR. ROY D. MCLELLAN.[8]—In our work on the spectrography of lead we are particularly interested in extending the limits of the sensitivity of the different elements occurring as impurities. In our laboratory we are interested in the study of the physical properties of lead, and the spectrography that must accompany such an investigation is dealing in a great many cases with very small quantities of impurities. Frequently it would be very desirable to have a still greater degree of sensitivity than we now possess.

Perhaps the most radical difference in our procedure, as compared with those more commonly used, is that in order to get this greater sensitivity we find it necessary to use the metal itself and completely burn a weighed sample in the arc. In most instances, a 25-mg. sample is used. This small amount must truly represent the sample as a whole, which previously has been rendered homogeneous. Wet methods simplify the problem of obtaining representative samples, but they do not yield the degree of sensitivity we require.

We found it necessary to develop a technique for synthesizing homogeneous standards, in which we would start with lead that gave no spectral lines of the impurity in question. With the help of binary equilibrium diagrams, it was possible to synthesize highly accurate alloys containing one impurity in lead. A complete series of synthetic binary standards involving each impurity (one at a time) was made, and the relationships between line intensities and concentrations of the impurity were established.

In commercial lead a number of impurities may be present. Theoretically, it would be desirable to have all of these impurities in each of the synthetic standard alloys, since the spectral line intensities may be slightly modified by the presence of other elements. However, the production of a reliably homogeneous multicomponent synthetic alloy is an extremely complicated problem. It is better to study the spectrography of binary systems of known composition than to base results on studies of many-component systems whose composition is less certain.

It will be left to later investigations to find out just how the various other elements affect or modify these spectral line intensities.

MR. H. V. CHURCHILL.[9]—It seems that in this discussion we have gone over, for one reason or another, to the discussion of minute amounts of impurities. While the spectrograph is suited to such determinations, I think there are many metallurgists and engineers who are interested in something besides these small traces, or worrying about whether copper is accurately determined to a millionth of a per cent. This was admirably illustrated by the work of Dr. Vincent, emanating from the University of Michigan, in the determination of amounts of elements that are of importance to the metallurgist and the engineer and to the user of metals in everyday use. Now the determination of small amounts, of course, is of great importance. We cannot minimize the influence of these small amounts, but it also becomes of great importance to know about the manganese content, the chromium content, the magnesium content and the copper content, and I think it would be unfair if we did not bring out the fact that a lot of these determinations, in what you might call macro amounts, is being done. Of course, back of every good spectrographical laboratory there must be a good, first-class chemical laboratory, and the only reason we are using spectrographic methods is because they are faster or cheaper or more reliable.

One of the things that I think we should not lose sight of is speed and I think we can say this—spectrography gives adequate accuracy.

I call attention to a publication of the British Non-Ferrous Research Association—their Publication 524 on Quantitative Spectrographic Analysis, with a Microphotometer. When you get out of range of some of these things where the eye is pretty good on comparison, you get into the use of some type of microphotometer. One of the sanest views that has been given of the use of the spectrograph for determining macro amounts is given in this report of the British Non-Ferrous Research Association. It is a compilation of the published literature by D. M. Smith, who, I believe, is associated in some way with the Research Association. It is inclusive and takes up real practical questions. Over in the latter part of the

[8] Spectroscopist, American Smelting and Refining Co., Perth Amboy, N. J.

[9] Aluminum Company of America, New Kensington, Pa.

publication it gives recognition to the work in this country and also to that in Germany. There is an excellent bibliography which specifically tells, for example, exactly how some workers determine magnesium and other elements. One method determines magnesium from 0.1 to 4 per cent, and iron and silicon up to 0.5 per cent. Another method determines magnesium from 0.1 to 8 per cent in aluminum-silicon alloys. It includes methods that are in use in Germany and England for the analysis of duralumin. A good series of methods is given for copper alloys, for lead alloys, for magnesium alloys, for tin alloys and for zinc. There are also references to certain work being done on steel. We had hoped to be able to present something of the spectrographic work of my own company, but that did not prove possible at this time. We are going into the analysis of virgin aluminum, that is, as produced by electrolysis. Analyzing spectrographically for iron, silicon, and copper in such metal is comparatively simple. We are going into such work purely on the basis of time saving. It is a question of mass production of analyses. We use it in one plant at the present time where a particular lot of work requires 40 man-hours to do it chemically. We are able to do it spectrographically in about 6 hr. The point we wish to make is that it is not particularly faster in elapsed time, due to the nature in which samples are gathered, but it does save 33 out of 40 man-hours, which represents a saving of somewhere around 70 per cent in point of time. We are interested in the accuracy and precision of these results. In the past, routine chemical results have been used, so we have made comparisons with the same work done chemically. We have found that on such a basis the spectrographic results show adequate accuracy and precision. We believe that there are many conditions to be controlled, but once you do control them it is our experience thus far in our work that there is less subjectivity in these spectrographic densitometric results than there is in the chemical results on our particular type of work. As yet we have not applied the spectrograph on a quantitative basis to the routine analysis of aluminum alloys in our plants.

Mr. J. T. Mireles Malpica.[10]—In connection with the paper presented by Mr. Strock, I would like to point out that the photographic plate is quite important, and I would like to have the reaction of more people regarding it. In the linearity range, that is, when working with suitable densities, it does not matter which method of analysis is used, whether one uses just millimeter ratios or relative intensities. However, when the densities approach the background values, it would be desirable to state definitely that condition and also what type of standards were used to arrive at that determination, whether they have the same basic matrix as the sample being analyzed or not. I should like to have Mr. Strock's comments on my statement.

Mr. Strock.—In answer to the last point, the matrix of standard mixtures and samples to be analyzed should always be as similar as possible. The tolerance of similarity depends on the element in question, and to some extent on the technique employed. The art of spectrochemical analysis, and especially the science, is too young to permit formulation of definite rules. The little existing knowledge on the effect of the matrix consists of scattered individual observations. A few are very serious. The mass of matrix effects, undoubtedly, are due to incompletely consumed samples, especially in cases where the spectrum was derived from some empirically selected portion of the arcing process. It must be remembered that the arcing is a distillation process which separates the different elements (and compounds) present according to their boiling points. Furthermore, quantities of elements with low ionization potential produce a low temperature arc (for example, alkalies), whereas silica, alumina, and other refractories as oxides of cerium, zirconium, titanium, produce a high temperature arc and remain unvolatilized until the alkalies, etc., are completely vaporized. The determination of refractory elements and compounds combined as silicates by reference to mixtures of a high alkali content matrix, will lead to trouble. In my experience the analysis of both alkali-poor and alkali-rich silicates, shales, pure $CaCO_3$, and iron oxides each requires its own independent standard mixtures. In practice the constituent oxides of a synthetic silicate must be pressed and sintered before use as a standard matrix.

In reply to the question on the photographic process, I summarized briefly in my paper the results obtained to date on this subject. There are naturally always certain things one must do in devising specific methods in order that they may be applied with confidence. Testing photographic material is one of them. The manufacturer, however, is in a position to supply color sensitivity and contrast curves for his emulsions, as well as reciprocity and grain size distribution curves. I have, therefore, confined my studies to photographic factors as they reveal themselves in spectrochemical methods. Much work still remains to be done in this direction.

Mr. T. M. Hess.[11]—I would like to ask Mr. Malpica, in reference to his work, whether I understood him correctly to say that he intended to continue the study of these plates, and, if so, how he intended to store the unexposed plates prior to use in order to be sure that any change in emulsion characteristic from plate to plate is not due to some deterioration accelerated by temperature.

One other question is—how far from the edge of the plate did he put the spectrograms?

Mr. Malpica.—Each plate has two spectrograms at about $^3/_4$ in. from the edges of the plate. The characteristics that we showed are for the range from 2900 to 3600 Å. We wanted to place the two spectrograms as far apart as possible without getting a bad edge effect. Once a plate is exposed and measured we are through with that plate. Some time later we shall order more plates of the same type and test them again in order to rule out individual variations and arrive at characteristics for that particular type of plate.

Mr. E. B. Ashcraft[12] (*by letter*).—There are three categories into which spectrographic analyses may be divided: qualitative, comparative, and quantitative. The dividing lines are not sharp, but nevertheless differences between

[10] General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

[11] Spectroscopist, Dow Chemical Co., Midland, Mich.

[12] Research Engineer Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

these three classes are very real. Methods for reporting the results of analysis in the last two cases are quite straightforward. In the case of the comparative analysis the absolute amount of the constituent present is relatively unimportant and it suffices to say that there is more or less in one sample than the other. A quantitative analysis is, of course, reported numerically. The precision of the method should be included as a ± term.

In the case of a qualitative analysis the reporting is more difficult. This difficulty arises from the fact that a purely qualitative analysis is of little value; experience has shown that some estimation of amounts is always demanded (and rightly so) by the user. In other words, a qualitative analysis is in reality always a semiquantitative analysis. In work of a research or investigational character a large number of these semiquantitative analyses is performed and the useful reporting of results is an important problem.

In attempting to meet this reporting problem, the following scheme is in use at the Westinghouse Research Laboratories. A mimeographed sheet, reproduced below, has been freely distributed among the users of analyses. The scheme is neither ideal nor final. It is expected that from time to time it will be revised both as to limits and as to form. But for the present it has been a very satisfactory solution of the problem.

Method for Reporting Qualitative Spectrographic Analyses

In making a qualitative spectrographic analysis it is usually possible to estimate within one or two orders of magnitude the amounts present. This estimation is a guess based on a knowledge of the conditions of excitation, a subjective comparison of the blackness of lines, and previous experience. It is important to stress, on the one hand, that an analysis of this type should not be made to appear more quantitative than it is; on the other, that for many purposes estimations to the limits given are adequate. It is thought better to designate different amounts by letters rather than by numbers indicating the two limits. The third column in the table below indicates limits within which none of our estimations has as yet been shown to be incorrect. The fourth column indicates probable limits.

		Limits Never Yet Exceeded, per cent	Probable Limits, per cent
A	Major Constituent	100.0 to 1.0	100.0 to 10.0
B		50.0 to 0.5	50.0 to 5.0
C	Minor Constituent	10.0 to 0.1	10.0 to 1.0
D		1.0 to 0.01	1.0 to 0.1
E	Trace	0.1 to 0.001	0.1 to 0.01
F	Faint Trace	0.01 to 0.0001	0.01 to 0.001
G		0.001	0.001

MR. H. A. BRIGHT.[13]—Speaking as a member of the Inorganic Analytical Section of the National Bureau of Standards, I wish to state that our section has had very little to do in the field of accuracy requirements involved in formulating specifications covering the composition of metallurgical materials. We are, however, concerned that such specifications be reasonable ones. When material is submitted under questionable specifications, and conditions permit, the necessity of revision is suggested. Some time ago we received some dental tools with specifications calling for 0.62 to 0.64 per cent carbon and 17 to 18 per cent chromium. Just how and why such specifications originated we do not know, but as a result of our questioning the specifications, they now read 17 per cent minimum chromium and 0.60 to 0.70 per cent carbon.

While I am unable at this time to contribute any first-hand experiences to a discussion on limits of accuracy involved in preparing specifications, I should like to mention briefly the helpful aid we have received from the Bureau's spectroscopic laboratory and also mention the matter of standard samples for spectrochemical analysis of steels and irons and possibly other alloys.

In our laboratories standard samples and special materials are surveyed spectrochemically before a chemical analysis is made. This is more particularly of aid in the determination of constituents present in small amounts. For example, in the determination of calcium in electrical-heating alloys information as to the presence or absence of barium is important. Then when an analysis has been made we often ask the spectroscopic laboratory to check the products obtained. For example, in the analysis of the National Bureau of Standards standard bronze 52*a*, a determination of gallium on a 10-g. sample ended, after a goodly number of separations, in a residue of 0.3 mg. considered to be gallium oxide. The spectroscopist reported that gallium was the major element though the analyst was somewhat amazed to learn that about eight or ten of the common elements were also reported as present. Again, a great deal of time has been saved by having the spectroscopist check the performance of methods of separation of work being done on the separation of certain elements in the rare earth group and on another project on the separation of hafnium and zirconium.

As regards spectrochemical testing of alloys, we are at present doing some of this work. Fusible tin plugs for steam boilers, formerly analyzed chemically, are now being tested in the spectroscopic laboratory for compliance with a specification calling for less than 0.5 per cent copper, less than 0.1 per cent lead, less than 0.1 per cent zinc, and less than 0.7 per cent total impurities. We are now interested as to whether the bronze casings for these plugs, now being analyzed chemically, can be tested spectrochemically to meet specifications calling for a minimum of 84 per cent grade B copper, 9.0 per cent tin and zinc combined, and a maximum of 2.5 per cent lead; and a maximum of 86 per cent grade C copper, 10 per cent tin and zinc combined, and a maximum of 0.3 per cent lead. Copper, tin, and zinc should be determined to an accuracy of 1 per cent and lead to about 2 per cent.

The spectrochemical work on tin also includes the testing of pig tin and tin-lined pipe. Some work is also being done on sheet lead. In this connection some comparative chemical and spectrochemical values obtained on a sample of lead during the course of some work of Committee E-3 in preparing methods of analysis of lead may be of interest (see Table I).

These data are presented not in the spirit of criticism but with the thought of promoting discussion on the utility and limitations of spectrochemical analysis.

As regards standard samples for spectrochemical analysis of steels, we have on hand the cores of the 5.5-in. rounds from which our standard steel samples are cut.

[13] Chemist, National Bureau of Standards, Washington, D. C.

TABLE I.—ANALYSIS OF LEAD.

	Laboratory A	Laboratory B	Laboratory C	Laboratory D
Copper, per cent	0.0012	0.0012	....	0.0006[a] (0.0015)*
Bismuth, per cent	0.022	0.022	0.024[a]	0.02[a]
Silver, per cent	0.0009	0.0009	....	0.00025[a]
Arsenic, per cent	0.0019	0.0018	0.0017 0.0013[a]	0.00175[a]
Antimony, per cent	0.0027	0.0029	0.0033 0.0027[a]	<0.0001[a] (0.0027)*
Tin, per cent	<0.0005	0.0007	....	<0.0001[a]

[a] Spectroscopic test.
* Subsequent chemical analysis.

These cores are about 1.5 in. in diameter and 3 ft. in length. If the composition of these cores is the same as that of the chips the cores could be machined into suitable electrodes or perhaps drawn into wire.

We are now machining a sheet brass for the renewal of the Bureau's standard sample 37*b*. Because of a change in cutting practice, the backing plates formerly employed are not needed. These plates are approximately 1/8 in. in thickness and 8 by 10 in., and offer possibilities of being cut into small sections or electrodes. This brass is a 70 per cent copper, 30 per cent zinc with about 1 per cent lead, 1 per cent tin, 0.6 per cent nickel, 0.1 per cent iron, and other minor impurities.

As regards the chemist's interest as to whether the spectroscopist can meet the accuracy requirements of the iron and steel industry it would appear that the answer to this question is given in the recently published articles in *Metal Progress*, *Iron Age*, and the *Journal of the Iron and Steel Institute* (1939) on the routine spectroscopic control analysis of irons and steels at the Ford Motor Co., Fairbanks, Morse and Co., Lackawanna plant of the Bethlehem Steel Co., and the Admiralty Laboratory, Sheffield.

MR. WRIGHT.—To the academic spectroscopist or the impatient engineer practical papers and discussion such as we have listened to may not represent progress. Many questions have been raised and comparatively few answered. One may perhaps suggest that that in itself furnishes proof that there is room for further study and that much benefit will in time ensue. Provocative questions often are in the long run more inspirational and productive of real progress. Let us hope that has been in a measure true here. Committee E-2 is very grateful for the helpful interest shown.

Aircraft Materials Testing Discussed at Los Angeles Meeting

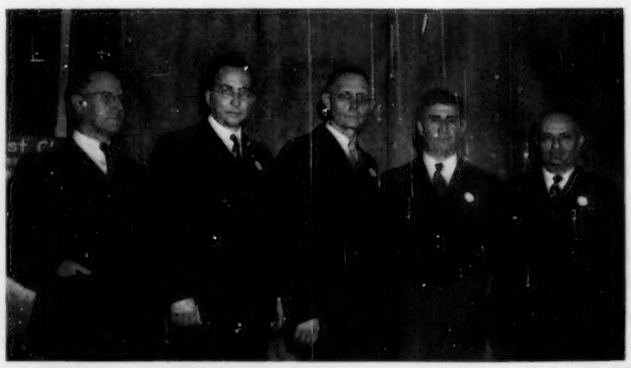
ONE OF THE BEST attended and most successful meetings yet held by the members and guests of the Society in the Southern California District took place on February 20 at the Riverside Breakfast Club in Los Angeles, at which time the Southern California District Committee had arranged for Dr. W. B. Klemperer of the Douglas Aircraft Co., Santa Monica, to present an address on "Material Testing Problems Arising from the Advance in Aircraft Performance." This meeting took place during Secretary-Treasurer C. L. Warwick's trip to the Pacific Coast, to which reference is made elsewhere.

Both President W. M. Barr and the Secretary-Treasurer spoke at the meeting, Doctor Barr giving a brief and entertaining extemporaneous talk, and Mr. Warwick covering a number of phases of the Society's work, its growing significance and the increasing recognition of this fact, and how it can best be of service in connection with the present National Defense efforts.

Doctor Klemperer, who before his connection, beginning in 1936, with the Douglas Aircraft Co., was for twelve years Manager of the Research Department, Goodyear Zeppelin Corp., presented a most interesting and instructive paper. This was illustrated with slides and in addition he had arranged displays of a number of instruments and pieces of equipment which were available for inspection after the meeting. Since Doctor Klemperer has agreed to edit his paper and submit it for publication in the ASTM BULLETIN, only brief reference need be made in this news note to the principal problems discussed. These included descriptions of conditions that are encountered at high altitudes and with present speeds, and their effect upon various parts of the plane as well as the pilot and flying personnel. Delicate instruments have been developed which measure the strain on some parts of the plane in specially constructed laboratories; certain conclusions have been drawn from the results with respect to materials and design.

Total attendance at the dinner was 180, and a number of others joined the audience to hear the speakers. Invitations had been extended to a number of representatives of various service branches of the Government and to engineers and scientists representing the various aircraft and other industries of Southern California. A number of these men attended including Commanders Deewall, Arnold, and other officers and personnel of the Office of Inspector of Naval Material.

Details for this very successful meeting were handled by John Disario, Metallurgist, Columbia Steel Co., chairman of the district committee, and E. O. Slater, Vice-President and Manager, Smith-Emery Co., secretary. Both of these men were in close touch with Mr. Warwick during his five-day stay in Los Angeles. Among various events was an executive meeting of the District Committee attended by Messrs. John Disario, E. O. Slater, F. J. Converse, T. A. Fitch, E. F. Green, H. W. Jewell, H. E. Jung, and R. G. Osborne, at which there was full discussion of A.S.T.M. work, how this affects the Southern California



E. O. Slater, C. L. Warwick, W. M. Barr, W. B. Klemperer, and John Disario.

industries, how best the members can effectively aid in advancing the Society's activities, and related matters.

From the attendance figure it is evident that the committee received good support from the members in the area, one of whom, instead of making his usual trip of 45 miles to attend a meeting, had to go by a circuitous route totaling some 70 miles necessitated by weather conditions.

Detroit Meeting April 18 on Changes in Materials Due to Defense

EACH SPRING THE A.S.T.M. Detroit District Committee has sponsored an outstanding meeting of A.S.T.M. members and others concerned with the field of materials featuring, usually in the form of a symposium or group of papers, some topic pertinent to the Society's work. At a recent meeting of the District Committee, it was decided to sponsor the District meeting on April 18. Four outstanding technologists will discuss phases of the topic "Changes in Materials Due to Defense Requirements." The subjects to be covered and the authors of the papers are as follows:

Non-Ferrous Metals—J. S. Laird, Ford Motor Co.
Chemicals and Plastics—J. K. Hunt, E. I. du Pont de Nemours & Co., Inc.
Rubber—S. M. Cadwell, United States Rubber Co.
Ferrous Metals—E. C. Smith, Republic Steel Corp.

It is the plan that each of these papers will take about fifteen minutes. A dinner will precede the technical session, arrangements for this being made by C. H. Fellows, Head, Chemical Division, Research Dept., The Detroit Edison Co., vice-chairman of the committee. W. C. Du Comb, President, W. C. Du Comb Co., Inc., is handling matters in connection with announcements and publicity, and J. L. McCloud, Metallurgical Chemist, Ford Motor Co., chairman of the district committee, is handling details of the technical program. Martin Castricum, Manager, Textile Section, Product Development Division, United States Rubber Co., secretary of the District Committee, is responsible for other meeting details.

Further announcement of the place of the dinner and meeting will be made to all members in the Detroit area.

Cleveland District Discusses Specifications

A VERY INTERESTING meeting of the Cleveland members of the Society and their guests was held on the evening of January 30 at the Hotel Allerton, under the auspices of the Cleveland District Committee. The meeting was preceded by a dinner at which the Chairman, Arthur J. Tuscany, Managing Partner, Tuscany, Turner and Associates, presided. About 135 members and guests participated.

At the conclusion of the dinner Mr. Tuscany introduced the chairmen or other representatives of a number of the Cleveland sections of engineering and technical societies who were among the invited guests. The Secretary-Treasurer, C. L. Warwick, spoke on the cooperative phases of the Society's specification and research activities with illustrations of specific projects being carried on in cooperation with some of the organizations represented at the dinner.

At the evening technical session, with about 300 present, James H. Herron, President The James H. Herron Co. and past-chairman of the District Committee, presided. After a few words from the Secretary-Treasurer regarding some aspects of the relationship of A.S.T.M. to the National Defense Program, Mr. Herron explained that the object of the meeting was to have a free and unrecorded discussion on the subject of specifications in the present defense emergency with particular reference to cast metals, pipe and tubing, and general iron and steel products.

F. G. Steinebach, editor of *The Foundry*, presided over the seminar on Cast Metals. Fred J. Walls, International Nickel Co., spoke on gray iron castings, H. A. Schwartz, National Malleable & Steel Castings Co., on malleable castings, and C. W. Briggs, Steel Founders' Society of America, handled the question of steel castings.

H. R. Redington, Chairman, Specifications Committee National Tube Co. was in charge of the pipe and tubing session with Ralph L. Wilson, Climax Molybdenum Co., and H. C. Weirick, Timken Roller Bearing Co., leading the discussions.

The subject of general iron and steel products was covered by L. B. Grindlay, Republic Steel Corp.

The meeting brought to light a number of interesting points with considerable pertinent discussion. It was generally agreed that the session was very worth while.

District Meeting in San Francisco

THE NORTHERN California District Committee arranged two very interesting luncheons at the Engineers' Club in San Francisco during Secretary-Treasurer Warwick's recent visit to the Pacific Coast. On Tuesday, February 11, practically the entire District Committee met with the Secretary-Treasurer for luncheon for discussion of various administrative and other matters dealing with district committee affairs. Present at the luncheon were chairman F. M. Harris, secretary T. P. Dresser, Jr., and Messrs. Dozier Finley, R. A. Kinzie, M. C. Poulsen, G. H. Raitt, J. B. Terry, and Dennistoun Wood. Alan D. Jones, Manager, Central Station Department, General Electric Co., newly appointed member of the committee, was also present for his first meeting.

On Thursday, February 13, most of the members of the committee attended a second luncheon at which a number of invited guests were present, among them Dean George L. Sullivan, College of Engineering, University of Santa Clara; Dean Samuel B. Morris, College of Civil Engineering, Stanford University; Frederick H. Reimers, President of Executive Board, Northern Section, State Association, American Institute of Architects; Prof. C. T. Wiskocil, President, Structural Engineers Association of Northern California (and College of Civil Engineering, University of California); Ralph Wadsworth, Director and Past President, San Francisco Section, American Society of Civil Engineers (representing Walter Dreyer, President of the Section); George Summerville, representing Local Section, American Society of Mechanical Engineers; and C. V. Fowler, Chairman, Local Section, American Society of Electrical Engineers, Pacific Telephone & Telegraph Co.

A very interesting discussion of the work of A.S.T.M. in relation to the activities of other societies featured the luncheon.

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Some Impressions from a Pacific Coast Visit

THE SECRETARY-TREASURER spent a most interesting and profitable two weeks on the Pacific Coast during February, meeting with the Northern and Southern California District Committees at San Francisco and Los Angeles, visiting with members, calling upon men in industries (notably aircraft manufacturing) who we feel should be in the Society and helping us in our work, and last, but not least, attending with President Barr a bang-up meeting of members and guests in Los Angeles. Some impressions of that visit are worth recording.

We have in the personnel of these two District Committees a group of men second to none in the Society in their sincere interest in A.S.T.M. and the desire to advance its interests in every way possible. They devote many hours to the consideration of Society affairs—how the influence of A.S.T.M. among the Pacific Coast industries can be extended and knowledge of A.S.T.M. standards and data on material promoted; how membership can be increased; how our Pacific Coast members individually and as a group can contribute effectively to the work of the Society, notwithstanding the handicap of distance—which despite streamline trains and airliners still remains something of a handicap. Out of their deliberations have come valuable suggestions regarding administration of district affairs, improvements in Society publications, modifications in standardization procedures, and increased participation of Pacific Coast industries in the committee work of the Society.

Thus, it is significant that 36 per cent of our members in California are serving on committees, which is not much less than the country-wide average of 42 per cent—excellent evidence of the interest in committee activities—on the part of members who can seldom attend meetings but follow the work and contribute through correspondence. At that, quite a few members attend one or more meetings a year. The two district committees are continually studying possibilities for extension of such contacts.

On every hand in California today one sees evidence of recent industrial expansion incident to the National Defense Program—especially in the Southern part of the state where aircraft construction and shipbuilding are centered. These two industries and the many that supply them with materials are straining every effort to meet the demands of the present emergency. With this has come a growing interest in the availability of technical knowledge on matters relating to design, processing, construction, and materials. Tremendous demand for materials of all kinds has placed a premium on the adequacy of knowledge of their properties, and how to test and specify for them, having in mind, too, the needs that may develop for substitute materials. In many of the plants visited an eagerness for knowledge of the properties of materials, of how to test them, and of adequate specifications for them, was very noticeable, so much so that the writer was strongly impressed with the opportunity that lies before our district committees and members on the Pacific Coast to spread knowledge of the Society and its work among the industries out there.

Among the various things that a district committee can do, the holding of meetings such as the one in Los Angeles is certainly among the most effective. By selecting technical subjects having a strong local interest and inviting persons to the meetings who have a special interest in the subject, an understanding of the Society and its work can be developed most effectively. The meeting in Los Angeles was an excellent example. The audience of nearly 200, many of whom were not members of the Society, showed a keen interest in Doctor Klemperer's excellent address and many also availed themselves of the opportunity to examine the Society publications which were on display and took with them BULLETINS, Indexes to Standards, and other literature which was available for distribution. We are indebted to the members of the Southern California District Committee in staging such an excellent meeting, and hope that others like it can be arranged during the coming year.

One further impression: There is much research being carried on through various channels—some of it no doubt stimulated by the industrial expansion that is taking place. Some of this work will, of course, be published through suitable channels; but infrequently we learned of studies dealing with materials the results of which would seem to command a fairly wide interest for which no plans for publication were being made. This suggests a possibility of more papers for our meetings and articles for the ASTM BULLETIN from our Pacific Coast members than we have customarily been receiving—a thought that has already been passed along to the district committees for their consideration.

All and all, the opportunities for wider utilization of the Society's work among the industries on the Pacific Coast and an increased participation of those industries in the Society work through membership and committee activities have never been more promising than they are today. The Society is fortunate in h ving its interests in this important region in the hands of the capable district committees centered in Los Angeles and San Francisco.

1941 Nominating Committee

AFTER REVIEWING the report of the tellers, R. B. Lewis, Chief Engineer, Tinius Olsen Testing Machine Co., and L. F. Parlette, Assistant Chief Engineer,

Philadelphia Transportation Co., on the recommendations of members for appointments on the 1940 Nominating Committee, the Executive Committee at its January meeting selected members of the committee. A meeting of the Nominating Committee was held in Washington on March 7 with the following designated members present:

A. T. Goldbeck	M. R. Paul
R. W. Lilley	T. S. Taylor
J. L. Miner	E. W. Upham

Past-Presidents A. E. White, T. G. Delbridge, and H. H. Morgan were also present as *ex-officio* members of the Nominating Committee in accordance with the By-laws which provide that it shall include the three last past-presidents.

Following the established procedure, the nominees for president, vice-president, and five new members of the Executive Committee will be announced in the May BULLETIN.

Discussion of Particle Size and Color Symposiums Requested by April 15

MEMBERS OF THE Society and others who wish to submit written discussion of the papers comprising the two Symposiums on Color and on Particle Size Measurement held as the technical features of the Washington Spring Meeting of the Society, are requested to submit copies of their discussion in duplicate as soon as possible. Committee E-6 on Papers and Publications has set April 15 as the closing date. Each of these symposiums will be issued in the form of a special publication including the discussion. Editorial work has already commenced on the Symposium on Color and publication of this book is expected by May 15, the volume on Particle Size Measurement to follow during the early summer. Each member will receive further announcements and an order blank giving the special prices to members.

Sustaining Members Total 133 on February 20

ANNOUNCEMENT IS made as of February 20 of the acquisition by seven leading companies of sustaining membership in A.S.T.M. bringing the total of organizations which support the Society through this means to 133. Like most of the companies whose activities have been previously reviewed in the BULLETIN as they became sustaining members, it will be noted these seven have been very active in technical committee work.

Full announcements have previously been made of the advantages of sustaining membership such as the receipt of a copy of *every* publication issued by the Society which includes quite a number ordinarily furnished only on purchase; a complete set of the Book of Standards and an extra set furnished on request; and extra copies of the ASTM BULLETIN which can be procured by sustaining members for distribution to their executives and engineers who are following A.S.T.M. work.

From the Society's standpoint the growing list of sustaining memberships is extremely significant because it establishes a broader base of financial support and enables organizations which inherently benefit greatly from A.S.T.M. to support it in a degree more nearly commensurate with its value to them.

Sustaining members contribute $100 dues yearly while other corporate or company members pay $30. Individual membership, which also applies to government departments, universities, libraries, and the like, is $15.

New Sustaining Members

IRVINGTON VARNISH AND INSULATOR CO., C. F. HANSON, TECHNICAL DIRECTOR, IRVINGTON, N. J.

Affiliated with the Society as a company since 1921 this organization has been active through its technical representatives on several A.S.T.M. committees, in particular, Committees D-9 on Electrical Insulating Materials and D-13 on Textile Materials. Mr. Hanson who has represented this membership for over ten years has for a like period been active in the work of D-9, and is Chairman of its Subcommittee I on Insulating Varnishes, Paints and Lacquers. He serves on two other subcommittees and is a member of the Advisory group. On D-13 his activities have been primarily in the field of glass fiber. Byron Adams is at present representing the company on Committee D-20 on Plastics.

THE RIVERSIDE METAL CO., H. L. RANDALL, PRESIDENT, RIVERSIDE, N. J.

For over 15 years Mr. Randall has been the official representative in the Society of this membership which dates back to 1914. A leading organization in the field of non-ferrous metals and alloys, the company through its representative, R. J. Wheeler, Metallurgist, has been active on numerous subcommittees of both Committees B-2 on Non-Ferrous Metals and Alloys and B-5 on Copper and Copper Alloys, Cast and Wrought. Mr. Wheeler was the former Chairman of B-5's Subcommittee II on Copper-Tin Sheet and Strip and at present serves on five subcommittees. In B-2 he represents his company on the groups concerned with refined copper; refined lead, tin, antimony and bismuth; white metal alloys; refined zinc and wrought zinc; and precious metals and alloys.

BIGELOW-SANFORD CARPET CO., INC., J. N. DOW, TECHNICAL DIRECTOR, THOMPSONVILLE, CONN.

This organization which is particularly active in connection with the work of Committee D-13 on Textile Materials has been a company member of the Society since 1935. At the present time in addition to Mr. Dow, two others are on D-13; namely, D. C. Higley who serves on Subcommittee B-5 on Sampling, Presentation, and Interpretation of Data, and Harold Le Duc who is a member of the section on pile floor coverings of Subcommittee A-3 on Wool and Its Products. Mr. Dow is chairman of this last-named subcommittee and is a member of the subcommittee on bast and leaf fibers, the section on atmospheric conditions of Subcommittee B-1 on Methods and Machines and is a member of the D-13 Advisory Committee.

REVERE COPPER AND BRASS INCORPORATED, E. S. BUNN, ASSISTANT DIRECTOR OF RESEARCH, NEW YORK CITY.

This company which is very actively concerned with A.S.T.M. has supported it through a number of memberships. In addition to its sustaining membership which it transferred from a company membership held since 1927, it is continuing the company affiliation of the Baltimore Division dating from 1924. At the present time four of the company's engineers and technical executives are personal members. Richard A. Wilkins, Vice-President, whose office is in Rome, N. Y., has been affiliated with A.S.T.M. since 1930; Dexter H. Mead, Supervisor of Methods, of the Dallas Division in Chicago, since 1927; Frank W. Harris, Super-

visor of Methods, of the Michigan Division in Detroit, since 1935; and E. S. Norris, Technical Advisory Dept., New Bedford, Mass., since 1939. Mr. Wilkins has been a member of Committee B-5 on Copper and Copper Alloys, Cast and Wrought, from 1931 and is a former subcommittee chairman. Mr. Bunn has served for several years on a large number of subcommittees of B-5, is chairman of the subgroup on copper-nickel-zinc sheet and strip, and is a member of the Advisory Committee. He also represents Committee B-5 on the Section on Indentation Hardness of Committee E-1 on Methods of Testing.

THE AMERICAN ROLLING MILL CO., ANSON HAYES, DIRECTOR, RESEARCH LABORATORIES, MIDDLETOWN, OHIO.

For many years this company has been active in the work of the Society not only through a company membership but through individual memberships held by company executives. C. W. Rust, Electrical Engineer, Research Dept., has been affiliated personally with A.S.T.M. since 1920; Reid L. Kenyon, Research Metallurgist, since 1930; and Ralph H. Gelder, Works Metallurgist, at the Ashland, Ky., branch, since 1931. The President, C. R. Hook, a former representative of the company served a term on the A.S.T.M. Executive Committee from 1929 to 1931. With respect to technical activities these have been confined primarily to the field of ferrous metals, the company having been represented on Committee A-1 on Steel by several men beginning in 1931, Committees A-5 on Corrosion of Iron and Steel, A-6 on Magnetic Properties, and A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys. Mr. Hayes serves on the steel committee and the corrosion committee and is a past-chairman of the subcommittee on interpretation and presentation of data of Committee E-1 on Methods of Testing. Mr. Kenyon is active in E-1 work dealing with indentation hardness, thin sheet metals, and effect of speed of testing. R. B. Dimmick, Chief Metallurgist, and T. F. Olt, Research Laboratories, serve on the steel committee. Arba Thomas, in addition to recent membership on Committee A-5, is concerned with the work of Committee E-3 on Chemical Analysis of Metals, serving as chairman of its Division A on Ferrous Metals and is a member of other subgroups.

MONSANTO CHEMICAL CO., KENT R. FOX, CHEMICAL SALES ENGINEER, ST. LOUIS, MO.

Intensely interested in many phases of the Society's work involving the field of chemicals and related products this company has been affiliated as an organization since 1936. Mr. Fox has been the representative. J. E. Viscardi, Engineer in Charge of Physical Testing, at Springfield, Mass., is a personal member of the Society. Mr. Fox for a number of years has been a member of Committee D-19 on Water for Industrial Uses and is also serving the Society as a member of the St. Louis District Committee. D. E. Baker, Rubber Service Labs., at Akron, Ohio, serves on A.S.T.M.'s committee on rubber products. J. C. Harris, of the Thomas & Hochwalt Labs. in Dayton, Ohio, has for a number of years been on Committee D-12 on Soaps and Other Detergents in connection with his work at the laboratories. H. K. Nason, Assistant Director of Research, Plastics Division, Springfield, Mass., continues his work on Committee D-20 on Plastics which work was transferred from the Fiberloid Corp. when Monsanto took over this company. P. E. Marling, Thomas & Hochwalt Labs., serves on Committee D-1 on Paint, Varnish, Lacquer, and Related Products.

COMBUSTION ENGINEERING CO., INC., JOHN VAN BRUNT, VICE-PRESIDENT, ENGINEERING, NEW YORK CITY.

In acquiring sustaining membership this company, affiliated as an organization with A.S.T.M. since 1921, effected a transfer of another company membership held at the Hedges-Walsh-Weidner Division in Chattanooga, Tenn., to a personal membership in the name of A. J. Moses, General Manager. Both Mr. Van Brunt and Mr. Moses have represented memberships in the Society for many years, Mr. Van Brunt having formerly held a personal membership since 1921. A number of the company's technical men and executives are active in committee work. Mr. Van Brunt is concerned particularly with the work of Committee D-5 on Coal and Coke and is Chairman of Subcommittee VII on Pulverizing Characteristics of Coal. A. G. Weigel, Assistant to the President, has served for several years on Committee A-1 on Steel and certain of its subcommittees. E. C. Chapman represents the company on the committee on radiographic testing.

Administrative and Editorial Staff Appointments

THE EXECUTIVE COMMITTEE has created the following three positions within the staff of the Society, and has appointed to these positions the members of the present staff whose names are given:

Standards Editor	P. J. Smith
Assistant to the Secretary	R. J. Painter
Assistant Editor	G. A. Wilson

Mr. Smith has been on the Society's staff since 1927. He graduated in Civil Engineering from the University of Pennsylvania in 1926. After a brief experience with Day and Zimmerman he came with the Society, where he has been engaged principally in editing and publishing committee reports and standards, and administrative work largely in connection with committee activities. For some years he has been in immediate charge of the editing and publishing of standards. As Standards Editor, he will have more complete responsibility for this work, which as our members know is growing every year in volume and importance. He will continue his present administrative and technical work, which includes the Secretaryship of Committee E-1 on Methods of Testing and Society representative in such important cooperative work as the A.S.M.E. Boiler Code Materials Committee and the Iron and Steel and Non-Ferrous Metals Divisions of the S.A.E.

Mr. Painter has been with the Society since 1931. Following his graduation in Civil Engineering from Rensselaer Polytechnic Institute in 1928, he taught at the Institute for a year and then went with the Bethlehem Steel Co. for two years. His work with the Society has been principally with the ASTM BULLETIN, Exhibits of Testing Apparatus, advertising and general promotional activities, including membership and sales promotion. He has also served for several years as Technical Assistant to Committee A-1 on Steel, where he has done much to facilitate the work of that large committee. In recent years much of his time has been devoted to developing the BULLETIN into a more useful publication to our members, with particular reference to inclusion of technical articles. In addition to continuing in these capacities, as Assistant to the Secretary he will take over immediate responsibility for administration of District Committee activities.

Mr. Wilson has been a member of the staff since 1925. He attended the night school at Drexel Institute and obtained his diploma in Structural Engineering. His work with the Society has been largely on the editing and publishing of the technical papers and discussions (*Proceedings*), and in handling ably a multitude of meetings and publication details, including maintenance and analysis of publication cost records. He will continue in these capacities as Assistant Editor, and will take over increasing responsibility in the editing of papers for *Proceedings* and BULLETIN.

Notes on Society Finances

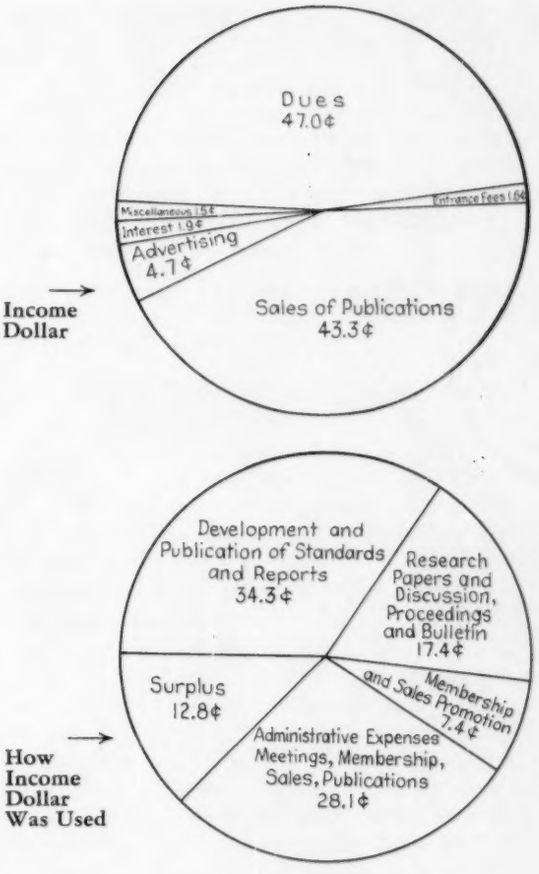
THE SECRETARY-TREASURER'S annual report to the Executive Committee on 1940 finances reveals interesting information on the year's operations.

The total operating (budgeted) receipts for 1940 were the highest in the Society's history, $188,879, comprising $91,928 from dues and entrance fees, $81,639 from sales of publications, and $15,312 from advertising, interest and dividends, and miscellaneous sources. Sales of publications (which include sales to members as well as nonmembers) were at an all-time high; this is partly accounted for by heavy sales of the Book of Standards following its publication in revised form in 1939, but is also a reflection of the constantly increasing demand both within and outside of the Society membership for copies of A.S.T.M. standards in the various forms in which they are made available.

The operating (budgeted) disbursements were $164,623, which include payment of all expenses for current publications as well as establishment of a reserve of $6000 toward the 1942 Book of Standards. It will be seen that there is a favorable balance between receipts and disbursements of $24,256. The year 1940 is the first of a three-year budgeting period necessitated by triennial publication of the Book of Standards, and it is gratifying to begin this period with a substantial favorable balance since it will be necessary to apply some portion of it for operation of the Society in 1941 and 1942, during which years the volume of sales of the Book of Standards will naturally diminish compared to 1940. The Executive Committee views with satisfaction the strengthening of the reserve of the Society, which has never been large and which may be needed in the uncertain times ahead.

An interesting and revealing way of presenting the story of 1940 finances is to show the source of the 1940 income dollar and how it was spent, as set forth in the accompanying charts. It will be seen that about half of the income of last year came from dues and entance fees and somewhat over four-tenths of it from sales of publications, the latter being an unusually high ratio for reasons mentioned previously. About 87 cents of the income dollar was spent for purposes indicated, the remainder representing surplus as explained above.

These charts serve as another reminder that the Society's services to its members cost considerably more than the income from dues and that these services are made possible by the substantial income from sales of publications which constitutes an important source of industry and government support of the Society's activities.


Income Dollar
Dues 47.0¢
Miscellaneous 1.5¢
Interest 1.9¢
Advertising 4.7¢
Entrance Fees 1.6¢
Sales of Publications 43.3¢
How Income Dollar Was Used
Development and Publication of Standards and Reports 34.3¢
Research Papers and Discussion, Proceedings and Bulletin 17.4¢
Membership and Sales Promotion 7.4¢
Administrative Expenses Meetings, Membership, Sales, Publications 28.1¢
Surplus 12.8¢

1941 BUDGET

The budget for 1941 is based upon estimated current receipts of $172,000, of which $93,000 is from dues and entrance fees, $61,500 from sales of publications, and $17,500 from advertising, interest and dividends, exhibit, and miscellaneous sources. Operating disbursements have been budgeted at about $177,000, which has required an appropriation of about $5000 from surplus for current operations. The budget of disbursements provides for an expansion of the staff necessitated by the growing activities of the Society; also for all of the regular and a number of special publication activities, likewise a reserve of $6000 toward the next triennial Book of Standards. Appropriations for district committees have been increased in view of the growing importance of this work, and the sum of $1000 has also been provided for emergency expense in relation to National Defense activities.

Technologists Needed by the Government

AN ANNOUNCEMENT to this effect has been received from the U. S. Civil Service Commission which has been in touch with the Society in connection with the pressing problem of filling important Government positions. As a measure of further cooperation we are publishing the announcement in the hope that a number of members may be in a position to refer the matter to associates or friends who would be interested. While obviously most members of the Society and their staffs are under heavy pressure because of demands resulting from national defense work, if any thoughts do occur to them, it is suggested they contact the Commission. A statement from the Commission follows:

"The U. S. Civil Service Commission has announced an open competitive examination to secure Technologists for National Defense work. Difficulty is being experienced in filling positions in such branches of technology as explosives, fuels, plastics, rubber, minerals, and textiles. Persons qualified in these branches are particularly urged to file application. Applications will be rated as received until *December 31, 1941*.

"The duties of the positions include the planning, conducting, and reporting of investigation or research in some specialized branch of technology such as explosives, fuels, plastics, rubber, minerals, and

textiles; or the testing, designing, or manufacturing of the materials essential for the successful operation of an industrial plant where such plant operation is based on some specialized branch of technology. Applicants must have completed a 4-year college course with specialized major study except that they may substitute, year for year, for the required education, professional experience in the appropriate fields of science, engineering, or technology. In addition, applicants must have had a certain number of years of professional experience in appropriate fields, the number of years varying with the grade of technologist; graduate study in an appropriate field may be substituted for a part of this experience.

"The positions to be filled are in several grades with salaries ranging from $2600 to $5600 a year. Competitors will not be given a written test but will be rated upon their education and experience.

"Further information and application forms may be obtained from the Secretary of the Board of U. S. Civil Service Examiners at any first- or second-class post office, or from the United States Civil Service Commission, Washington, D. C."

Separate Standing Committee on Electroplating Organized

Personnel Announced; Actions on Standards

With the organization of the new Committee B-8 on Electrodeposited Metallic Coatings, effected during Committee Week in Washington, on March 6, plans that had been under discussion last year on realignment of the Society's work on electroplating have been put into effect. Probably the first work carried on by the Society in this field was that by Committee A-5 on Corrosion of Iron and Steel. As a corollary of its work on exposure tests of coated iron and steel, the committee developed specifications for coated products. Similarly Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys reached the point where it believed that the specifications for various coated non-ferrous materials should be prepared and work was initiated with this in view. Committee B-6 on Die-Cast Metals and Alloys was also interested in the plating of die-cast products. In view of the common interest of these several committees, it was felt that the work could be handled more efficiently if it were segregrated in a separate committee since the problems incident to the several materials had a great deal in common. After consultation with the various committees, a new committee on electroplating was accordingly authorized by the Society's Executive Committee, the preliminary statement of scope being as follows: The formulation of specifications and methods of test for electrodeposited metallic coatings with the exception of zinc and cadmium applied to steel.

A steering committee consisting of E. A. Anderson (Chairman), William Blum, W. H. Finkeldey, C. H. Sample, Sam Tour, and J. R. Townsend assisted the Executive Committee in the selection of the initial personnel. Mr. Anderson was designated temporary chairman and under his guidance organization was effected, with the election of the following committee officers:

E. M. Baker, *chairman*, Prof. of Chemical Engr., University of Michigan, Ann Arbor, Mich.

E. A. Anderson, *vice-chairman*, New Jersey Zinc Co., Palmerton, Pa.

Gustaf Soderberg, *secretary*, Technical Director, The Udylite Corp., Detroit, Mich.

A list of the personnel at this time follows:

Personnel of Committee B-8

Aluminum Co. of America, J. J. Bowman
American Brass Co., A. W. Tracy
American Chain & Cable Co., Inc., B. Westerman
American Electro-Platers' Society, A. B. Wilson
E. M. Baker, University of Michigan
Bell Telephone Labs., Inc., H. G. Arlt—C. H. Sample, Alternate
William Blum, National Bureau of Standards
Bridgeport Brass Co., W. E. Baulieu
Carnegie-Illinois Steel Corp., E. S. Taylerson—R. A. Dimon, Alternate
Chase Brass & Copper Co., Inc., B. H. McGar
Crane Co., R. H. Zinkil
Doehler Die Casting Co., J. C. Fox
Du Pont de Nemours & Co., Inc., E. I., Grasselli Chemicals Dept., L. R. Westbrook
W. H. Finkeldey, Singmaster & Breyer
General Electric Co., W. L. Maucher
General Motors Corp., W. M. Phillips
A. K. Graham, Jenkintown, Pa.
C. E. Heussner, Chrysler Corp.
G. B. Hogaboom, Hanson, Van Winkle, Munning Co.
International Nickel Co., Inc., R. J. McKay
Glen F. Jenks, U. S. Army, Ordnance Dept.
Charles A. Marlies, College of the City of New York
New Jersey Zinc Co., E. A. Anderson
Scovill Manufacturing Co., W. B. Price
Erwin Sohn, Standard Sanitary Manufacturing Co.
Sam Tour, Lucius Pitkin, Inc.
Udylite Corp., Gustaf Soderberg
U. S. Navy, Bureau of Ships, Navy Dept., E. C. Forsyth—K. D. Williams, Alternate
U. S. War Dept., Quartermaster Corps, A. J. Buckley
Western Electric Co., Inc., A. M. Wagner

In connection with certain organization problems and to expedite committee work, an Advisory Committee was set up at the meeting to consist of the newly elected officers and the members of the steering committee.

The following specifications, formerly under the jurisdiction of Committee A-5, have been assigned to this new committee:

Tentative Specifications for Electrodeposited Coatings of Nickel and Chromium on Steel (ASTM A 166 – 40 T)

Tentative Methods of Test for Local Thickness of Electrodeposited Coatings on Steel (ASTM A 219 – 40 T)

The committee took under immediate consideration standards that have been under development in Committee B-3 and it is proposed to recommend at the A.S.T.M. annual meeting in June proposed new specifications covering:

Electrodeposited Copper-Nickel-Chromium Coatings on Zinc and Zinc Base Alloys

Electrodeposited Nickel-Chromium Coatings on Copper and Copper Base Metals

There was considerable discussion as to the type of subcommittee organization that should be set up. These subcommittees could either be according to type of coating, type of base material, or according to the use of the material. This question will receive further consideration at a future meeting of the committee. Approval of a final statement of the committee's activities will also await action some time in the future.

Committee Week;

Action on Standards

(*Continued from page 12*)

tion on the properties and tests of the respective products covered. Committee A-7 has been active along these lines and at the meeting there was discussion on information and data which are available on the creep resistance of malleable iron and the effect of small amounts of chromium on this material. An effort is to be made by the committee to have these data correlated and possibly offered for presentation at a meeting.

In connection with the work on yield point and yield stress, R. D. Landon, Professor of Civil Engineering, Southern Methodist University, who is a consulting member of A-7, presented a paper at the 1940 A.S.T.M. Annual Meeting covering "Stress-Strain Relations for Malleable Cast Iron in Tension with Special Attention to Yield Point Determination." One of the A-7 subcommittees covering air furnace and electric malleable iron was requested to review the results of Professor Landon's paper and consider whether any changes in specifications are necessary because of the information developed.

Iron-Chromium-Nickel and Related Alloys

The extensive tables of data covering the corrosion-resistant and heat-resistant alloys being compiled are rapidly being completed, it was announced, and it is hoped that the tables can be issued the latter part of this year. Committee A-10 will include in this compilation comprehensive data on chemical analysis, mechanical properties, heat treatment, etc., of the various stainless steels which tabulation will replace and bring up to date similar information published by the Society in 1930.

Subcommittee VI on Metallography reported completion of its studies of structural constituents and etching of the 18 per cent chromium, 8 per cent nickel types of alloy steel. The results of this investigation which have included the micrographic examination of specimens of these types of steel after various heat treatments using several etching reagents for revealing carbides will be included in the 1941 report.

Another phase of the committee's program is work to be undertaken in cooperation with the Alloy Castings Research Institute and the American Petroleum Institute on the studies of the test block for heat-resisting alloys recently made at the Battelle Memorial Institute and their relation to the A.S.T.M. specifications for stainless steel castings.

Refined Nickel and High Nickel Alloys

The subcommittee on these materials, functioning under Committee B-2 on Non-Ferrous Metals and Alloys has drafted eight new important specifications, and a revision of an existing tentative specification.

Three of the new specifications will cover nickel-chromium-iron alloy sheet, plate and strip; tubes; and bars. A companion group of three other proposed standards pertain to nickel sheet, plate, and strip; tubes; and bars. The subcommittee also acted on revisions to be submitted in the Specifications for Nickel-Copper Alloy Plate, Sheet, and Strip (B 127 – 39 T) and reported the completion of two new specifications for nickel-copper alloy tubes, and bars.

All of these nine specifications, after approval by subcommittee letter ballot, will be submitted to Committee B-2 for inclusion in its 1941 report.

Corrosion of Non-Ferrous Metals and Alloys

The results of extensive total immersion tests which have been carried out in five different laboratories were considered by Committee B-3, and while some anomalous results were reported in parts of this testing program, if these can be satisfactorily explained, it will be posible to announce a standardized procedure for total immersion testing which will give concordant results in various laboratories.

Subcommittee VI on Atmospheric Corrosion presented a statistical analysis of the very voluminous one-, three-, and six-year exposure data on 22 different metals exposed at nine different locations. This important information will be included in the 1941 report.

A new subcommittee is being organized to be known as Subcommittee V on Statistical Analysis and Planning of Corrosion Testing. This group will act as adviser to the other subcommittees in the planning of their programs and in the analysis of the data resulting from that program.

Another new subcommittee (VII on Weather) will attempt to collect the pertinent data in connection with weather at the various test locations. In this case the term "weather" includes such things as sulfur dioxide, soot, dew, sunlight, wind velocity, temperature fluctuation, etc. If, as, and when data of this kind with respect to specific test locations can be correlated with the results of exposure tests at these locations, the subcommittee may undertake the collection of similar data with respect to other locations.

Copper and Copper Alloys

Committee B-5 on Copper and Copper Alloys, Cast and Wrought formulated plans for the organization of a new subcommittee on tolerances. This subcommittee will cooperate with the standards committee of the Copper and Brass Research Association, acting as a liaison group on dimensional tolerances between producers and consumers of wrought copper and copper-base alloys.

Revisions were presented in four specifications for Leaded Brass Sheet and Strip (B 121 – 39 T), Brass Sheet and Strip (B 36 – 40 T), Gilding Metal Sheet and Strip (B 130 – 40 T), and Cartridge Brass Sheet, Strip and Disks (B 19 – 40 T).

Activity on miscellaneous copper-base wire and rod alloys was very pronounced, with the completion of four proposed specifications covering respectively manganese bronze rod; copper-nickel-zinc alloy rod and wire; phosphor bronze wire; and phosphor bronze rods, bars, and shapes. Subcommittee V also reported that it had in preparation new specifications for aluminum bronze rods, bars, and shapes, for general engineering purposes,

and for hardware and commercial bronze rods and bars. Revisions were presented in the specifications covering Free-Cutting Brass Rod (B 16 – 29), Copper Rods, Bars and Shapes (B 133 – 40 T), Seamless Copper Tubes (B 75 – 40 T), and Seamless Copper Tubing, Bright Annealed (B 68 – 39 T).

The subcommittee on copper-base alloys for sand castings has been especially active during the past year having completed seven proposed new standards for sand castings. These will be companion standards to the Specifications for Copper Alloy Ingot (B 30 – 40 T).

A list follows:

Specifications for Sand Castings

Tin-Bronze and Leaded Tin-Bronze
High-Leaded Tin-Bronze
Leaded Red Brass and Leaded Semired Brass
Leaded Yellow Brass Sand Castings for General Purposes
High-Strength Yellow Brass and Leaded High-Strength Yellow Brass
Aluminum-Bronze
Leaded Nickel-Brass (Leaded Nickel-Silver) and Leaded Nickel-Bronze (Leaded Nickel-Silver)

Several tests for copper alloys have been studied and two methods have been completed covering respectively the pin testing of copper tubing material, and the mercurous nitrate test.

Die-Cast Metals and Alloys

Committee B-6 on Die-Cast Metals and Alloys, which has had great influence in the development and use of various die castings through its extensive research work and in the development of standard specifications, considered at its dinner meeting methods of financing an extension of atmospheric exposure tests on zinc, aluminum, and magnesium alloy test specimens. The previous tests at various locations extending over some ten years need to be supplemented by information on new alloys, and a special committee has been appointed to solicit contributions from a large number of producers and consumers of this type of casting.

A committee consisting of J. R. Freeman, Jr., Chairman, J. C. Fox, and Sam Tour was appointed to investigate and report whether there was sufficient interest in brass die castings to warrant the formation of a new subcommittee. This subject, when discussed, elicited few comments other than that there would be considerable interest in brass die casting if die steels with satisfactory life could be obtained. Since the search for these has been attempted unsuccessfully, it seemed unlikely that brass die castings would increase greatly in commercial importance in the near future. However, there may be a need for specifications for the parts now being produced as brass die castings and this phase of the problem is also to be considered by this committee.

The proposed changes in the composition of Zinc Base Alloy XXV (B 86 – 38 T) raising the minimum magnesium from 0.02 to 0.03 per cent and the maximum tin from 0.002 to 0.005 per cent will be submitted for approval.

Papers covering the up-to-date methods for the finishing of aluminum, zinc, and magnesium alloy die castings are expected to be ready for presentation at the 1941 annual meeting.

Requirements have been agreed on for a new alloy to be known as No. 13X. This alloy is to be the same as Alloy No. 13 in the Specification B 94 except that the iron and nickel contents are held to low values (0.005 per cent maximum) in order to obtain maximum resistance to salt water corrosion. Mechanical properties are considered the same as for Alloy No. 13 which will run 29,000 to 34,000 psi. tensile strength; 2 to 5 per cent elongation in 2 in.; 1 to 3 ft-lb. Charpy impact value.

Light Metals and Alloys

Steps it might take to assist in overcoming a number of production problems which have arisen because of the great demand for various types of aluminum and magnesium alloys, were studied by Committee B-7 on Light Metals and Alloys. One of its actions concerned a review of the specifications for aluminum for use in iron and steel manufacture which now cover four grades. Certain changes are to be made to help in connection with the heavy demand for this type of material.

A production bottleneck in connection with aluminum sand castings has been the time involved and the equipment necessary for heat treating certain type castings to produce high strength. A recent development in this field is a new aluminum alloy which has high-strength properties in the as-cast condition, thus eliminating the heat treating requirements. Fortunately, this new alloy can be easily cast and with its high-strength combines good corrosion resistance.

With reference to aluminum sheet and strip specifications the committee is attempting to help in connection with supply by revising size tolerances in keeping with present production facilities.

In connection with magnesium alloys in all forms the committee is proposing new high purity grades. These offer greater resistance to salt water corrosion than the normal grades. Except for this, the alloys apparently have no better properties than the normal grades. Obviously, the high purity alloys are available from limited sources of supply and at premium prices.

Concerning anodic oxidation treatment of aluminum and aluminum alloys for added corrosion protection and abrasion resistance the committee is beginning a program of tests. Samples of various alloys have been treated by different methods and will be tested by cooperating laboratories.

Fatigue of Metals

The Research Committee on Fatigue of Metals considered the first draft of its 1941 report which consists mainly of data on the investigation of effect of type of fatigue testing machines on test results. Three general types of machines were studied in seven different laboratories and results on three typical metals—heat-treated alloy steel, low-alloy steel and duralumin—were obtained.

There was quite good agreement from the different types of machines as to the limiting stress which a metal would withstand for an indefinitely large number of cycles of stress, the endurance limit or fatigue limit. There was more variation and "scatter" of results when the length

of "life" was determined for specimens subjected to reversed stresses above the endurance limit. There was noted a distinct "size effect," larger specimens showing lower endurance limit than smaller, except for the duralumin specimens.

Plans for a further study of this "size effect" and of the effect of "residual" stresses in metal were made.

Fire Tests of Materials and Construction

At the meeting of Committee C-5 on Fire Tests of Materials and Construction, W. J. Krefeld of Columbia University submitted on behalf of Subcommittee II on Fire Tests of Lumber a newly developed method for testing wood chemically treated by impregnation to reduce flammability. If approved this will be submitted to the Society as a proposed tentative test. This method was accompanied by an extended report of comparative fire tests of treated and untreated wood giving the results of an elaborate series of tests conducted during the past three years independently at five different laboratories, as the basis for the standard.

After full discussion of the tentative revisions in the Methods of Fire Tests of Building Construction and Materials (C 19 – 33) it was voted to recommend their adoption, with some minor changes.

On the basis that certain investigations now under way at the U. S. Forest Products Laboratory would have influence and the probability that the new test submitted by Subcommittee II might be found applicable to the testing of treated wood used for scaffolding and similar temporary use, it was decided to recommend the continuation as tentative of Specifications for Fire-Retardant Properties of Wood for Scaffolding and Shoring (C 132 – 40 T).

The committee will recommend, after ballot, that the Methods of Fire Tests of Door Assemblies (C 152 – 40 T) be adopted. In taking this action, Committee C-5 indicated its desire to continue studies respecting the determination of smoke and fumes that might be passed by the door assembly during the test. Also, further studies are to be given to the applicability of the test results to door assemblies of larger size than the specimen under test.

Questions on the effect of the hose stream test in evaluating assemblies to which are applied the shorter duration tests are to be investigated.

Lime

A working subcommittee on lime in mortar, submitted a preliminary report to Committee C-7 on Lime which included a discussion of the contribution of lime to the properties desired in mortars, and a brief résumé of the present knowledge of lime in mortar gained from studies made by investigators in the United States and foreign countries. A comprehensive bibliography on the subject was appended. It was decided to submit the report and bibliography to Committee C-12 on Mortars for Unit Masonry for its consideration.

For the purpose of standardizing test conditions in connection with investigations on mortars, the following values were assigned to cubic foot quantities of the usual ingredients in mortars:

Lime hydrate solids*	50 lb. per cu. ft.
Portland cement	94 lb. per cu. ft.
Sand	80 lb. per cu. ft.

*A 50-lb. bag of hydrated lime shall be considered as one cubic foot of material. When quicklime putty is used, 50 lb. of solids in sufficient putty shall be considered one cubic foot of lime hydrate solids.

An investigation of hydrated limes is to be made looking toward a revision of the Specifications for Hydrated Lime for Structural Purposes (C 6 – 31) which would establish a maximum limit on the unhydrated oxides of calcium and magnesium.

Based on a canvass of the purchasing practices of leading varnish manufacturers no revisions seem to be necessary in the Specifications for Hydrated Lime for Varnish Manufacture (C 47 – 27).

It was decided to initiate a series of tests on the various sugar and other methods for determining available lime for the purpose of standardizing on a simple and fairly accurate method which can be used by the producer and consumer of lime products. The subcommittee on methods of test has under way the development of analytical methods for determining the amount of arsenic, fluorine, and lead which may be present in lime used in the manufacture of food products.

Data are being collected by the committee on the various methods used in slaking quicklime on the job for the purpose of duplicating these conditions in the laboratory and preparing a laboratory procedure on the slaking process.

Another committee action authorized the initiation of a study on the factors which influence the settling rates of quicklimes and hydrated limes used for chemical purposes.

Refractories

One of the major projects of Committee C-8 during 1940 was the incorporation in its purchase specifications of the new classification of fireclay brick and in revising these standards which covered materials for malleable furnaces, for stationary boiler service and for refractories for construction of incinerators; they were rewritten in the form of tentative specifications and the one for stationary boiler service was divided into two documents covering heavy-duty and moderate duty service. These four specifications are to be approved for adoption as standards. The Classification of Insulating Block and Insulating Fire Brick (C 155 – 40 T) which is based upon shrinkage as determined by heat treatment at specified temperatures and by bulk density is to be revised by which the bulk specific gravity will be lowered.

Other tentative standards to be adopted include those covering Methods of Chemical Analysis of Chrome Ore and Chrome Refractoies (C 18 – 40 T), Classification of Fireclay Refractories (C 27 – 40 T) and Method of Test for Warpage of Refractory Brick and Tile (C 154 – 40 T), and certain tentative definitions of terms which were issued under the designation C 71 – 40 T.

Last year tentative revisions were published for trial in the Standard Specifications for Ground Fire Clay (C 105). By these, the screen size requirements were to be made more rigid, a super-duty class of clay was incorporated and methods of sampling shipments of ground

clay in bulk and in containers was prescribed. All of these changes are to be adopted.

Concrete and Concrete Aggregates

Four important new tests and specifications are to be offered to the Society for approval at its annual meeting in June in Chicago, by Committee C–9. The three test methods for which there has been definite demand will cover the sampling of wet concrete, methods of determining volume of air entrained in concrete, and standardized procedures for determining the thickness of cores drilled from a concrete structure.

The proposed new tentative specifications for ready-mixed concrete which if accepted will comprise a tentative revision of the existing standard covering this material, C 94, include a number of improvements brought about in part by progress in this industry, and increasing demands for the material. In proposing the new requirements, Committee C–9 felt it desirable to keep the present standard in effect for the time being.

Other recommendations which will be offered involve revisions in the following tests and specifications:

Method of Test for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate (C 88 – 39 T)

Method of Test for Abrasion of Coarse Aggregate by Use of the Los Angeles Machine (C 131 – 39)

Specifications for Lightweight Aggregates for Concrete (C 130 – 39)

Gypsum

In order that certain requirements in the Specifications for Gypsum Partition Tile or Block (C 52 – 33) may be more in line with the Federal Specifications, Committee C-11 agreed on certain modifications which will be offered for immediate adoption as standard.

Consideration is also being given to the incorporation of the so-called ammonium acetate method for determining the purity of gypsum as an alternate to the gravimetric method, considerable data on this subject having been referred to the committee.

In the Methods for Testing Gypsum and Gypsum Products (C 26 – 40), the committee will propose that the sections on absorption tests (both total and rate of absorption) be deleted for the reason that no requirements on this property are incorporated in quality specifications and consequently the method seems unnecessary.

One of the important activities of the Society committees is in connection with nomenclature and standardizing of terms and definitions. Committee C-11 has developed changes in the terms covering gypsum lath, gypsum wall board and gypsum sheating board which will be recommended for adoption as standard. The committee will also recommend the dropping of the definitions of the term "gypsum plaster board."

Manufactured Masonry Units

An important action at the meeting of Committee C-15 on Manufactured Masonry Units was the acceptance for letter ballot of proposed specifications for filter block. There has been need for the establishment of purchase specifications for this type of vitrified clay and shale block used in sewage and water purification plants.

The committee also accepted a recommendation from its working committee on test methods to refer to letter ballot for adoption as standard the present Method of Freezing-and-Thawing Test of Brick (C 67 – 39 T), and to include this in the general test methods for brick (C 67 – 39).

The subcommittee on clay building brick announced that an extensive revision was in preparation of the present Tentative Specifications for Building Brick (Made from Clay or Shale) (C 62 – 40 T).

Thermal Insulating Materials

Studies have been in progress on a number of methods in current use for determining the physical properties of preformed insulation. As a result, proposed standard methods have now been completed for determining the crushing strength and flexural strength of preformed block thermal insulation. Also proposed definitions for preformed block insulation and for thermal insulating cement will be submitted to the Society for publication as tentative.

The subcommittee which deals with studies of the physical properties of plastic insulation reported the completion of several new methods. These cover a detailed procedure for mixing thermal insulating cements and complete methods of test for covering capacity and volumetric change upon drying, and a test for bulk density.

In the field of blanket, flexible, loose-fill and miscellaneous insulation the committee completed a new method of test for determining the thickness and density of blanket type materials.

The Joint Committee on Thermal Conductivity of all Forms of Insulation sponsored by four organizations, namely, American Society of Heating and Ventilating Engineers, American Society of Refrigerating Engineers, National Research Council, and A.S.T.M., has developed a method of test for the determination of thermal conductivity by use of the guarded hot plate method. Further study is to be given this method by the joint committee before submitting it to the sponsors.

Paint, Varnish, Lacquer, and Related Products

In the work of Committee D-1, on drying oils, proposed specifications were approved covering oiticica oil. This material will have been treated to render it permanently liquid and the requirements cover such matters as specific gravity, acid number, iodine number, which is indicated as 135 min., Wijs. This group also approved for publication as information in the ASTM Bulletin requirements covering dehydrated castor oil, which is to be in two types, unbodied and bodied.

There has been a great deal of interest in the work dealing with accelerated tests for protective coatings. The use of laboratory weathering cycles for determining the color (tint) retention of house paints continues. Certain cycles have shown indication as being acceptable and in connection with this work exposures in various localities are being studied in order to get definite evidence on the range of variations that occur climatically so that they can serve as a guide for interpreting laboratory results. A proposed specification covering methods for preparing panels for tests of enamels on steel has been

developed. The requirements cover the type of steel to be used and there are two methods of preparing the surfaces.

One of the interesting results of this work has been the tabulation of returns on an extensive questionnaire sent out to determine the interest in and extent of use of accelerated testing and other questions which are important to guide the committee in its work. It is planned to recommend the publication of the complete report. In general it was encouraging to note the relatively large percentage of people who have found certain types of accelerated tests very helpful in determining one or more specific phases of film breakdown and there was agreement that these quick tests have a bright future under proper conditions. The questionnaire developed extremely pertinent data on types of breakdown which are evaluated in order of importance by those responding and which, of course, vary according to the type of material and whether for indoor or outdoor use.

The work on methods of analysis of paint materials is continuing with cooperative tests under way on the spatula leafing method for aluminum powder and paste, and the group expects a report at the June meeting of the Society in Chicago on the consistency of house paints. Various samples are to be tested using present A.S.T.M. Method D 562 (the modified Stormer viscosimeter) and the Gardner mobilometer.

As a result of extensive work the subcommittee on varnish has developed two methods of test and a complete specification for liquid dryers. Note.—The two tests which cover cobalt and determination of iron are to be recommended immediately but a concurrent action on determination of color will be deferred pending results of investigations under way, even though there has been agreement on the procedures to be followed.

One of the important recommendations of the subcommittee on shellac was to change the tentative standard D 360. The proposed tentative Method for Determination of Color of Varnish and Shellac published in the August, 1940, ASTM BULLETIN is to be recommended as an A.S.T.M. test.

The work of the committee on physical properties in developing procedures for recording color is nearing completion. An article is being prepared for publication explaining in simple terms just what the method is to cover. Another development is a draft of a standard using the I.C.I. method and data in specifying color, and because of the importance of having definite requirements for panels for use on the specular gloss determinations, standardized requirements will be set up. Another important phase of this work involves tests for the adhesion of paint and varnish films and a standard procedure covering the preparation of uniform paint films.

In the work on cellulose ester coatings a new specification covering dibutyl phthalate is being recommended for publication and two existing test procedures for Toluene (Toluol) Dilution Ratio of Lacquer Solvents (D 268 – 39 T) and for Elongation of Attached Lacquer Coatings (D 522 – 39 T) are to be voted on for adoption.

The committee's policy of having technical papers and discussion presented at its meetings was continued with three papers. One covering various problems of adhesion was given by R. D. Bonney, Congoleum-Nairn, Inc.;

R. J. Moore, Bakelite Corp., and R. D. Bonney, Congoleum-Nairn, Inc.

another covered the question of film thickness given by Austen Allen of the New York Paint and Varnish Production Club; and the third covered discussion on gloss by R. S. Hunter, National Bureau of Standards. As indicated above, each of these subjects is of direct concern and ones on which various D-1 subcommittees are actively working.

Petroleum Products and Lubricants

The meetings of Committee D-2 on Petroleum Products and Lubricants were held on March 10 and 11 at the Hotel Washington, Washington, D. C., and a number of actions were taken, several of these involving important proposed standards. At its January meeting in Detroit the committee reported that as a result of the work of its subcommittee on pharmaceutical tests a procedure for determining carbonizable substances in paraffin wax had been drafted, which, based upon cooperative testing, appeared satisfactory. Committee D-2, after considering the possibility of combining this procedure with the present Test for Carbonizable Substances in White Mineral Oil (Liquid Petrolatum) (D 565 – 40 T) concluded that the two methods should be kept separate.

Based upon the insolubility of paraffin wax in methyl ethyl ketone at −25 F., a new procedure for determining the oil content of wax has been developed and further cooperative work will be done to determine the advisability of recommending the issuance of this method as a proposed standard.

The subcommittee on viscosity which earlier this year suggested the desirability of a third type of viscosity oil standard of low viscosity, in addition to the alpha and beta oils, reported in Washington on the correlation of conversions from viscosity expressed in centistokes at 122 F. and Saybolt Furol viscosity obtained at the same temperature. The subcommittee plans to publish the data for information.

The subcommittee on sulfur determination reviewed the unfavorable reactions to the proposed procedure of utilizing an oxygen-carbon dioxide combustion atmosphere in the lamp method for the determination of sulfur. It was voted to recommend a revision of the present Test for Sulfur in Petroleum Oils by Lamp Method (D 90 – 34 T) the changes being the use of the purified air supply, and the use of a fritted glass plate in the absorber.

As a result of cooperative work to evaluate a new procedure for saponification number which utilizes methyl ethyl ketone, the group concerned with neutralization number and saponification number recommended that this procedure be incorporated in Methods of Test for Saponification Number (D 94 – 39 T). Last year a proposed

method of test for neutralization number was published as information, and since experience with this procedure has proved satisfactory the subcommittee recommends that it replace the existing Tentative Method D 188 – 27 T. The subcommittee also recommended that the new so-called "General Motors Rapid Method" and a potentiometric method for neutralization number be published as information.

Among other actions taken is the recommended approval by A.S.T.M. as a tentative standard of the proposed test for aniline point of petroleum products published as tentative in 1940.

The subcommittee on gum has completed its work in endeavoring to "liberalize" the description and the dimensions of the apparatus specified in the Test for Gum Stability of Gasoline (D 525 – 40 T) and recommended the adoption of the revisions. The subcommittee also released the procedure for the determination of potential gum in aviation gasoline which it recommends be published for information and which will be used as the basis for future cooperative work on aviation gasoline stability.

A number of minor changes were recommended in the Test for Tetraethyl Lead in Gasoline (D 526 – 39 T). The subcommittee in charge plans to undertake cooperative work with other A.S.T.M. committees who are concerned with standardized procedures for determining lead.

One of the extremely important recommendations coming from the meeting is the recommendation to submit for approval as an A.S.T.M. tentative standard proposed specifications for aviation gasoline. These cover three grades with minimum octane numbers of 73, 91, and 100.

Gaseous Fuels

Accomplishments of groups of Committee D-3 on determination of calorific value, specific gravity, water vapor, and chemical analysis are particularly noteworthy. The subcommittee on determination of calorific value has been engaged for several months in preparation of a standard method for conduct of heating value determination by use of the flow calorimeter. Gases of 300 Btu. per cu. ft. and upwards are covered by the proposed procedures. These include both humidity control and humidity correction methods. Further revisions to tables are now being made preparatory to placing the proposed methods in complete form.

Work on approximately one-half the test gases selected for testing of various specific gravity instruments has now been completed at the National Bureau of Standards. These covered gravities from approximately 0.15 to 0.80. Additional work on the remaining test gases previously selected, which will cover range in specific gravity up to 2.0, is expected to be finished within the next few months. While much information on performance of various instruments under studying has been secured, data has not been made available pending completion of all tests. Consideration has also been given to effect of variations in compressibility and viscosity in the test gases. Although these qualities are not under direct study it has been considered advisable to determine their possible effects as the work progressed.

Much work has been conducted at Pennsylvania State College on two methods which had been previously selected for determination of water vapor. Apparatus has been developed for a precision method depending on infra-red absorption by water vapor. A second colorimetric method employing cobaltous bromide is now being developed for field work. It is proposed to publish results of studies made at Penn State and to include all work to date as well as a bibliography of the subject.

Results of analyses of synthetic manufactured gas samples submitted to approximately 30 cooperating laboratories have been tabulated and summarized by the National Bureau of Standards. These included results of about 225 analyses. Various methods were employed and a comparison given of results obtained by each. Some variation in the heating value and specific gravities of the samples, as determined by the analyses, was observed, this depending to a large extent on the method of analysis followed. Distribution is now planned of natural gas samples to the cooperating laboratories for analysis and report.

Coal and Coke

The adoption as standard of the present Method of Test for Index of Dustiness of Coal and Coke (D 547 – 39 T) is to be recommended by Committee D-5. This method first published in 1939 measures the relative dustiness of coal and coke when handled. It has proved of especial value in the evaluation of various processes for treating coal and coke in the production of so-called "dustless fuel."

Subcommittee VIII on Foundry Coke Specifications has labored for many years in an attempt to revise in satisfactory form the present Standard Specifications for Foundry Coke (D 17 – 16). These specifications were adopted in 1916 and have outlived their usefulness. The subcommittee after much study has concluded that it is not feasible to prepare general foundry coke specifications that will cover current foundry practices.

A special section of Subcommittee I on Methods of Testing was formed to consider methods of expressing tolerances on duplicate determinations when analyzing and testing coal and coke. The purpose of this work is to express such analytical tolerances on a precise mathematical basis in terms of probable error, standard deviation, etc. Precise methods are required in studies now being made attempting to correlate various chemical and physical properties of coal and coke with their use characteristics.

Paper and Paper Products

Committee D-6 on Paper and Paper Products has in preparation through its Subcommittee II on Significance of Test Methods, an extended report on use requirements and the significance of paper tests. It is planned to include a detailed discussion concerning the application of various tests used in evaluating different grades of paper. Information to be included will cover twenty-three types of tests such as bursting and tearing strengths, folding endurance, fiber composition, acidity, etc., on ten different types of paper such as printing paper, wrapping paper, tissue paper, bond, ledger, index, envelope paper, etc. It is also planned to discuss defects and foreign materials in paper and to cover as well the subject of color.

This committee has been active through two of its other subcommittees. The subcommittee on paper testing methods has under consideration some 16 additional test methods. It is expected that several of these new methods will be completed this year.

The subcommittee on fiberboard and fiberboard containers discussed at its last meeting the progress of the work under way on a cooperative study of bursting tests and a procedure for making compression tests on corrugated and solid fiberboard boxes.

Electrical Insulating Materials

Perhaps the most important announcement coming from Committee D-9 concerned the completion of four proposed standards. Three are testing methods and the fourth is an important specification covering phenolic tubes for radio use. The methods cover: 1, test for volatile content of vulcanized fiber; 2, sludge determination in insulating oil; 3, measurement of mica stamping in radio tubes and incandescent lamps.

Progress is being made on a test method of resistance of varnishes to various acids, alkalies and sea water. A method of determining internal drying characteristics of saturant varnish was discussed and plans completed for a final series of round-robin tests. Results on the methods of conditioning of specimens of shellac for flow test were also considered.

Work is continuing on phenolic molded material. Methods for conditioning specimens of sheet insulating material for insulation resistance, power factor, and electric strength were considered.

The group responsible for work on plates, tubes and rods reviewed with the Navy Department methods of testing the product uniformity of laminated phenolic sheet. Also, specifications of the Navy Department covering fish paper insulation were reviewed. Work is being done on the development of a standard test method for ply adhesion of vulcanized fiber.

Subcommittee IV on Liquid Insulation had several section meetings at which progress was made on standardizing methods of testing synthetic liquid insulation, gas content of oil, as well as the consideration in the main subcommittee on neutralization, sludge test, dielectric strength test, and significance of tests. A particular feature was a symposium on oil oxidation, including a presentation by Prof. J. C. Balsbaugh of work which he has been doing on oxidation. This has been carried out under the auspices of the Engineering Foundation, American Institute of Electrical Engineers, and Massachusetts Institute of Technology.

Among the important problems being considered by the group responsible for developing standards and data on solid filling and treating compound (Subcommittee VI) is the development of a method for determining the solubility of treating compounds in oil. The subcommittee on electrical tests has numerous projects including the power factor of insulation at frequencies of 100 megacycles. This work will include a revision of the Methods D 150 (tests for power factor and dielectric constant).

The committee plans to recommend the adoption of tentative test D 494 (acetone extraction of phenolic products) and will offer revisions in the test for power factor and dielectric constant (D 150) that include the ultra-high frequency method.

Rubber Products

Some of the new projects to be undertaken by Committee D-11 on Rubber Products as outlined in the following paragraphs will cover requirements for synthetic jackets for insulated wire and cable, testing of material to be used for battery box containers, and standardization of testing procedures applicable to rubber products manufactured by coating fabrics such as balloon cloth, draperies, upholstery materials, etc.

Proposed new methods of test for automotive air brake and vacuum brake hose have been completed; work on this subject was handled by Technical Committee A on Automotive Rubber (a joint SAE-ASTM group) and has resulted in specifications which will be published by the S.A.E., the test methods to be issued by A.S.T.M.

The Methods of Testing Rubber Belting (D 378 – 40 T) are to be adopted as standard, and the group in charge of specifications for products to protect persons from electric shock recommended that the specifications for rubber gloves (D 120 – 40) be referred to the A.S.A. for approval.

The Subcommittee on Wire recommended that a change be made in the Table on Thickness of Insulation and Alternating Test Voltage appearing in three standards for insulated wire and cable, D 27, D 353, and D 469, to includes sizes No. 16 and 18 A.w.g. for the 0 to 600 voltage classification because these sizes are not covered in the note.

The following tentative specifications are recommended for adoption as standard subject to letter ballot:

D 27 – 40 T—Insulated Wire and Cable: Class AO, 30 per cent Hevea Rubber Compound

D 353 – 40 T—Insulated Wire and Cable: Performance Rubber Compound

D 469 – 40 T—Insulated Wire and Cable: Heat-Resisting Rubber Compound

D 532 – 39 T—Rubber Sheath Compound for Electrical Insulated Cords and Cables

D 470 – 40 T—Methods of Testing Rubber Insulated Wire and Cable

An interesting program was developed by Subcommittee VI on Packings which included the presentation of the following papers:

Experiences in Packing a Cellophane Casting Machine, by William Staniar, E. I. du Pont de Nemours & Co., Inc.

Special Gaskets, by John Boyer, E. I. du Pont de Nemours & Co., Inc.

The Effect of Operating Variables on Performance of a Typical Centrifugal Pump Packing, by F. C. Thorn, Garlock Packing Co.

Tests of Packings for Refinery Services, by G. W. Oxley, Standard Oil Development Co.

The tentative revision covering buffing of samples in the Methods of Sample Preparation (D 15 – 39) is recommended for adoption as standard.

It is proposed to revise the Tentative Methods of Tension Testing of Vulcanized Rubber (D 412 – 40 T) to include in addition to the present three die shapes ($1\frac{1}{2}$ by 2 in., $\frac{1}{4}$ by 2 in., and $\frac{1}{4}$ by 1 in.) a new die $\frac{1}{8}$ by 1 in. with $\frac{5}{8}$-in. shoulders conforming to a similar die prescribed in the Federal specifications. As revised the methods are to be adopted.

The method for determining tear resistance of vul-

canized rubber (now a proposed draft) will be revised with respect to number of nicks and permissible thickness of specimen and attention will be given to the two proposed test specimen shapes. These changes are to be included in the 1941 report and the method submitted for publication as tentative.

The subcommittee on abrasion tests has decided to undertake work comparing the results obtained with the du Pont and Bureau of Standards machines to determine if data obtained by one test method can be correlated or converted into the other. The investigation of abrasion tests suitable for use in evaluating marine decking compounds will be undertaken.

A cooperative program has been arranged for comparing the results of accelerated aging tests with 80 C. bomb temperature and 70 C. Eleven laboratories are to cooperate using a number of different rubber compounds.

The Method of Test for Indentation of Rubber by Means of the Pusey and Jones Plastometer (D 531 – 39 T) is to be recommended for adoption as standard. A progress report was submitted on hand hardness testers (Durometers).

The subcommittee on dynamic fatigue testing considered a report of the effect of variables in rubber compounding on the results obtained in six recognized compression, flexing, and heat build-up tests on eight rubber compounds. It is expected that procedures for heat build-up testing by using compression flexing will be ready for presentation as a new tentative standard.

While proposed test methods for asphalt composition of battery box containers had been drafted and were presented by the subcommittee on hard rubber, discussion indicated that there is a need for more complete data.

A new Subcommittee on Standardizing Methods of Tests Applicable to Rubber Products Manufactured by Coating Fabrics (proofed goods such as balloon cloth, draperies, waterproofing materials, rubber blankets, upholstery materials, etc.) with Rubber and Rubber Like Materials has been authorized and is in the process of organization. A. F. Schildhauer of E. I. du Pont de Nemours & Co., Inc., is chairman of the new subcommittee. It is expected that an organization meeting will be held in June.

Textile Materials

The series of meetings held by Committee D-13 on Textile Materials were very productive and well attended.

The subcommittee on bleaching, dyeing, and finishing reported proposed tentative methods of testing moth proofing compounds for textile materials. At its meeting a number of problems dealing with the finishing of textiles were discussed. The subcommittee has recommended that work be undertaken dealing with the effect of finishing materials on the human skin and that this be done in cooperation with other interested groups. Revisions were acted on for inclusion in the method of test for resistance of textile fabrics and yarns to moths (D 582 – 40 T).

Another important matter concerns a new recommended practice for description of yarn construction which will cover all types of textile yarns. This will provide a shorthand description by use of numbers and symbols.

Terms defining the "Hand" of fabrics developed in cooperation with the American Association of Textile Chemists and Colorists were presented for inclusion in the D-13 Glossary of Terms Relating to Textile Materials, to be published as information.

The subcommittee on glass fiber and its products will undertake a study of the essential properties of sizing for glass yarn, including the preparation of methods of testing. This group is also investigating the important properties of glass sliver for wire insulation and for use as filler. In the four methods completed last year covering procedures for the testing of glass products, yarn, woven fabrics, tubular sleeving and braids, and woven tapes, a test method for pH value will be added this year. Methods for measuring resistance to abrasion of glass yarn and fabrics and for contraction of glass yarn due to twist are being developed. The subcommittee plans to cooperate with the Bureau of Ships, Navy Department, in developing methods of test for glass textiles for marine uses.

The adoption of the Specifications and Tests for Fineness of Wool Tops (D 472 – 40 T) with a revision covering the average micron value for grades below 50s, was recommended by the subcommittee on wool and its products. Studies of tests for shrinkage of grease wool (laboratory scale operations), D 584 – 40 T, may result in several revisions in the methods. This subcommittee has in preparation definitions for wool and a shrinkage test for wool felt.

The committee acted to recommend the adoption of the tentative revision in the Methods of Testing and Tolerances for Tire Cord, Woven and on Cones (D 179 – 38) which incorporates detailed requirements for sampling and prescribes the number of tests required for the various determinations. The requirements for sampling and the number of tests specified are the result of statistical studies made by the committee in accordance with the proposed recommended practice. The adoption of the procedure for calibration of thickness gages to be included in the Specifications for Textile Testing Machines (D 76 – 40) was approved.

Plastics

Several proposed standard methods of testing plastics were offered for approval at the meetings of Committee D-20 and results of a number of cooperative research projects were discussed.

The subcommittee on strength properties which has been studying technique and methods of compression, impact and tension testing of plastics reported that the tensile strength and impact test methods are being submitted for letter ballot.

In its work on hardness properties the subcommittee in charge reported data collected from the development of the scratch hardness test and submitted to Committee D-20 a proposed test method for the deformation under load at elevated temperatures. Data were submitted in connection with the development of a mar resistance test. The committee is undertaking a project to study plastic bearing materials and their frictional properties with a view to developing test methods.

Last year there was approved a Test for Flammability of Plastics (D 568 – 40 T) which is intended primarily for

determining flammability of materials in the form of thin sheets or films. A revision involving the addition of a benzol drop method of ignition was presented by the subcommittee on thermal properties. Satisfactory progress has been made in the cooperative series of tests of a rate of burning test procedure.

Methods for measuring softening point of plastics and flow temperature method for testing thermal setting materials are actively under consideration.

The subcommittee on optical properties reported the results of preliminary cooperative research on specimens tested in accordance with a proposed method of determining clarity. Progress is being made in the study of surface brightness and specimens have been prepared for a round-robin test on surface irregularities. A glossary for optical terms used in plastics is nearing completion.

A proposed standard test method for fastness to light of plastics was offered by the subcommittee on permanence properties. A test method for determining the resistance of plastics to heat is being drafted, and also a method for determining the permeability of water vapor by plastics. Test specimens have been prepared for investigation in various laboratories in an effort to simulate service conditions. The project was started to evaluate the weathering resistance of plastics and to formulate a testing procedure.

Committee D-20 voted to submit to letter ballot a definition of dry and moist room conditions, a standard of laboratory conditions for testing of plastics and proposed tentative methods of test for preconditioning of plastics and insulating materials which are also being voted on by Committee D-9 on Electrical Insulating Materials.

Soils for Engineering Purposes

The activity of most interest at the meeting of Committee D-18 on Soils for Engineering Purposes concerned the report of Subcommittee I on Terms and Definitions headed by William P. Kimball, Thayer School of Civil Engineering, Dartmouth College. Following discussion it was decided to refer to the entire membership of Committee D-18 for review and comment the report entitled "Soil Mechanics Nomenclature." It is hoped that the matter can be referred to letter ballot of the committee later in the summer and submitted to A.S.T.M.

Very intensive efforts have been made to obtain the broadest possible representation of engineering opinion. Following the circulation by Mr. Kimball's subcommittee in 1938 to a list of some 800 engineers, a list of symbols prepared by Professor Arthur Casagrande was sent to 60 engineers selected for experience in preparation of soil mechanics manuscripts and for their familiarity with literature. Two additional questionnaires were mailed and since then several revised lists have been reviewed.

Throughout the period of work the Subcommittee on Terms and Definitions of the Soil Mechanics and Foundations Division of the American Society of Civil Engineers has closely cooperated.

Paul E. McKinney

(1885–1941)

In the death of Paul E. McKinney, Metallurgical Engineer, Bethlehem Steel Co., who passed away at his home on February 18, the Society loses one of its most active members. In innumerable ways he contributed greatly to the advancement of the Society's purposes. Mr. McKinney lived only for about two weeks after suffering a stroke while driving.

He had been affiliated with the Bethlehem Steel Co. since 1929; formerly he was Superintendent of the Forge and Foundry Divisions of the U. S. Naval Gun Factory in Washington where he had served in various capacities since 1906. Previous to that he had been affiliated with the Reading Iron Co. and the Warwick Iron and Steel Co.

A member of the Society since 1915, Mr. McKinney had been extremely active in numerous phases of technical committee work, particularly in Committee A-1 on Steel. He was very active in the work of the Joint Research Committee on Effect of Temperature on the Properties of Metals, Committee B-5 on Copper and Copper Alloys, and Committee B-7 on Light Metals and Alloys, in the latter two committees serving on several of their subgroups. He was also a member of Committees A-2 on Wrought Iron, A-3 on Cast Iron, and A-9 on Ferro-Alloys, acting as a representative of his company on these three groups. He was also interested in the work on radiographic testing, serving on Committee E-7. He represented the Society on the Metallurgical Advisory Committee of the Advisory Committees to the National Bureau of Standards, and was a former member of Committee A-10 on Iron-Chromium-Nickel and Related Alloys.

As a member of the Philadelphia District Committee, only last December he acted as co-chairman of a meeting at which there was extensive discussion on the use of specifications.

In Committee A-1 on Steel his authoritative knowledge on the metallurgy and production of steel was particularly valuable in connection with three phases of its work covering steel castings, forgings, and materials for high-temperature service (nuts, bolting, and forgings). In all three fields he contributed a great deal.

In addition to his work in A.S.T.M. he was active in a number of other technical and professional organizations and was a member of a number of Government clubs and bodies.

At any period of time in the Society's work Mr. McKinney's loss would have been felt keenly, but especially so at a time like the present when his widespread and practical knowledge of the ferrous metallurgical field was invaluable to the Society and to the Government.

He is survived by his wife, the former Minnie S. Tenschert, whom he married in 1906; a son Frank, now in the employ of the Bethlehem Steel Co.; a daughter Helen, a grandson, his mother, and three brothers.

George B. Heckel

(1858–1941)

Since 1891 Mr. Heckel had been editor and publisher of the *Paint Industry Magazine*, formerly *Drugs, Oils and Paints*. He had been a member of A.S.T.M. since 1905, concerned particularly of course with the work of the Society in the field of paint, varnish, lacquer, and related materials. A member of Committee D-1 since he joined the Society, he served in numerous capacities and was a member of its Subcommittee IX on Varnish and also served on Committee D-10 on Shipping Containers. For many years he was Vice-Chairman of Committee D-1 and from 1918 to 1920 he served as a member of the A.S.T.M. Executive Committee.

He took a very active part in the extensive series of tests which Committee D-1 sponsored during the period prior to 1915, including the famous Havre de Grace bridge paint tests and the panel tests at Arlington and Atlantic City.

The author of a very interesting book entitled "Paint Industry—Reminiscences and Comments," he devoted a chapter to the work of the A.S.T.M and Committee D-1. He was very active in the work of other societies, in particular the Federation of Paint and Varnish Production Clubs which he helped to organize.

In the death of Mr. Heckel the Society loses a long-time member who for all the years of his membership was loyal to its interests, helped greatly in advancing its work, and through his facile pen did much to widen the knowledge of the activities of the Society.

NEW MEMBERS TO MARCH 14, 1941

The following members were elected from January 18 to March 14, 1941:

Company Members (17)

AMERICAN MANUFACTURING CO., R. C. Utess, Vice-President, Noble and West Sts., Brooklyn, N. Y.

AVONDALE MILLS, O. G. Edwards, Chemist, Sylacauga, Ala.

BRIGGS CLARIFIER CO., W. C. Bauer, Chief Engineer, 3262 K St., N. W., Washington, D. C.

BURNDY ENGINEERING CO., INC., Marvin Lee, Chief Engineer, 459 E. 133 St., New York City.

CADILLAC MOTOR CAR DIVISION, GENERAL MOTORS CORP., R. E. Cordes, Metallurgist, 2860 Clark Ave., Detroit, Mich.

CATALIN CORP., W. E. Flood, Director of Research, Fords, N. J.

CEMENTO PORTLAND NACIONAL S. A., Y. Soto, General Manager, Apartado 148, Hermosillo, Son., Mexico.

CHICAGO STEEL SERVICE CO., W. D. Monroe, Jr., Vice-President, 3912 S. Ashland Ave., Chicago, Ill.

CLAY PRODUCTS ASSN. OF THE SOUTHWEST, N. W. Kelch, Secretary-Manager, Box 4, Austin, Tex.

CROSLEY CORP., THE, L. M. Clement, Director of Engineering, Arlington St., Cincinnati, Ohio.

DITZLER COLOR CO., M. G. Bell, Assistant Director of Research, 8000 W. Chicago Ave., Detroit, Mich.

*FLINTKOTE CO., THE, Research Laboratory, East Rutherford, N. J.

GREAT LAKES CONCRETE PIPE CO., INC., M. C. Kelly, Vice-President and Chief Engineer, 9 Austin St., Buffalo, N. Y.

MANTROSE CORP., THE, F. S. White, Plant Superintendent, 136 Forty-first St., Brooklyn, N. Y.

NATIONAL BEARING METALS CORP., Robert Notvest, Metallurgist, 4930 Manchester Ave., St. Louis, Mo.

SCHUNDLER AND CO., INC., F. E., Henry Napier, 504 Railroad St., Joliet, Ill.

WAYNE DIVISION, BENDIX AVIATION CORP., C. G. Chambers, Chief Metallurgist, 36253 Michigan Ave., Wayne, Mich.

Individual and Other Members (60)

ARNOLD, J. E., United Shoe Machinery Corp., Beverly, Mass. For mail: Box 291, South Hamilton, Mass.

BARNWELL, MILDRED G., Executive Secretary, Southern Combed Yarn Spinners Assn., Gastonia, N. C.

BENEDICT, S. W., Assistant Materials Engineer, National Bureau of Standards, Washington, D. C.

BENNETT, F. V., Purchasing Agent, City of Sioux City, 401 City Hall, Sioux City, Iowa.

BEST, A. S., Associate Technologist, National Bureau of Standards, Washington, D. C.

BOWMAN, W. G., Editor, *Engineering News-Record*, 330 W. Forty-second St., New York City.

BYRD, J. F., Head of Laboratories, Marshall Field and Co., Manufacturing Division, Spray, N. C.

CAMPBELL, S. W., Research Director, The Flexite Corp., 223 W. Jackson Boulevard, Chicago, Ill.

CANTON PUBLIC LIBRARY ASSN., THE, 236 Third St., S. W., Canton, Ohio.

CARRIGAN, C. E., Metallurgist, Ranger Aircraft Engines Division, Fairchild Engine and Airplane Corp., Farmingdale, Long Island, N. Y. For mail: 37 Weiden St., Farmingdale, Long Island, N. Y.

CLARKE, K. E., Vice-President, Charles R. Long, Jr., Co., 1630 W. Hill St., Louisville, Ky.

CUYKENDALL, T. R., Assistant Professor of Civil Engineering, Cornell University, Lincoln Hall, Ithaca, N. Y.

DIEHL, HARVEY, Assistant Professor of Chemistry, Department of Chemistry, Iowa State College, Ames, Iowa.

DIRECCION GENERAL DE YACIMIENTOS PETROLIFEROS FISCALES BIBLIOTECA, Casilla Correo 1293, Buenos Aires, Argentina.

DIVINE, R. E., Research Chemist, Hooker Electrochemical Co., 304 Buffalo Ave., Niagara Falls, N. Y.

DONOVAN, J. P., General Building Contractor, 770 S. Schuylkill Ave., Philadelphia, Pa.

DOYLE, W. T., Vice-President, Sturtevant Mill Co., Boston, Mass. For mail: 327 Ashmont St., Dorchester, Mass.

EBERMAN, E. C., The Ferbert Schorndorfer Co., 12815 Elmwood Ave., Cleveland, Ohio.

EHRMAN, H. A., Technologist, National Bureau of Standards, Washington, D. C.

ELLER, J. W., Consulting Chemist, Milton Hersey Co., Ltd., 980 St. Antoine St., Montreal, P. Q., Canada.

ELLIOTT, J. K., Vice-President and General Manager, Pittsburgh Testing Laboratory of Texas, 1114 Commerce St., Dallas, Tex.

FAWCETT, F. K., President and General Manager, The Penn Manufacturing Corp., Box 484, Washington, Pa.

FITCH, R. L., Inspector, Air Corps, U. S. Army, Santa Monica, Calif. For mail: 506 Santa Monica Boulevard, Calif.

GILLAN, H. A., Purchasing Engineer, Eastman Kodak Co., Material Standards Dept., 343 State St., Rochester, N. Y.

HALL, E. D., Engineer of Tests and Chief Chemist, Erie Railroad Co., Meadville, Pa.

HALL, W. E., Chief Chemist, Egyptian Lacquer Manufacturing Co., Jacobus Ave., South Kearny, N. J.

HELD, S. W., Assistant Director of Testing, Hearn's Bureau of Standards, Hearn Department Stores, Inc., New York City. For mail: 563 New Lots Ave., Brooklyn, N. Y.

HAUTZENROEDER, R. W., Chief Engineer, Tractor Division, The Fate-Root-Heath Co., Plymouth, Ohio. For mail: 291 W. Third St., Mansfield, Ohio.

JACKMAN, C. H., Manager, Structural and Plate Bureau, Metallurgical Division, Carnegie-Illinois Steel Corp., 208 S. La Salle St., Chicago, Ill.

KAUFFMAN, J. R., Eastern Representative, Ferro Enamel Corp., Allied Engineering Division, Cleveland, Ohio. For mail: 29 Highland Drive, Milltown, N. J.

KANDIYOHI COUNTY HIGHWAY DEPT., E. S. Ward, County Highway Engineer, Willmar, Minn.

KERNAN, H. D., JR., Skenandoa Rayon Corp., Broad St., Utica, N. Y.

KETCHBAW, T. D., Manager, Industrial Welding and Testing Laboratory, 224 Hamilton Ave., Houston, Tex.

MANDIA, J. V., Chief Chemist, Des Moines Plant, Marquette Cement Manufacturing Co., Fifty-second St., and Park Ave., Des Moines, Iowa.

MANTZ, V. M., Development and Research Chemist, R. M. Hollingshead Corp., Sixteenth and Mickle Sts., Camden, N. J.

MARKER, R. H., Partner, Froehlich & Emery Engineering Co., 410 Second National Bank Building, Toledo, Ohio.

MCDONALD, L. M., Consulting Chemist, 69 Lexington Ave., New York City.

MOORE, ALICE C., Secretary-Treasurer, National Association of Finishers of Textile Fabrics, 40 Worth St., New York City.

MULL, E. K., Metallurgical Engineer, Bendix Radio Corp., 920 E. Fort Ave., Baltimore, Md.

NEUMAN, DANIEL, Fellow, Mellon Institute of Industrial Research, 4400 Fifth Ave., Pittsburgh, Pa.

NIESLEY, M. B., President, California Testing Laboratories, Inc., 1429 Santa Fe Ave., Los Angeles, Calif.

PHILADELPHIA TEXTILE SCHOOL, M. E. Heard, Dean, Broad and Pine Sts., Philadelphia, Pa.

PINGREE, R. A., Chemical Director, Textile Division, Warwick Chemical Co., 100 Pulaski St., West Warwick, R. I.

PINKERTON, R. R., Electrical Construction Engineer, The Sanitary District of Chicago, 910 S. Michigan Ave., Chicago, Ill.

RODGERS, J. S., Metallurgist, Wolverine Tube Co., 1411 Central Ave., Detroit, Mich.

ROGERS, R. M., Chief Engineer, Thompson Products, Inc., West Coast Plant, 8354 Wilcox Ave., Bell, Calif.

SIMMS, H. N., Metallurgist, Black, Sivalls & Bryson, Inc., Box 1377, Oklahoma City, Okla.

SINCLAIR, E. L., Materials Engineer, U. S. Maritime Commission, Washington, D. C. For mail: 4512 Yuma St., N. W., Washington, D. C.

SINK, M. VIRGINIA, Spectrographic Engineer, Chrysler

*See article on Sustaining Members, ASTM BULLETIN, No. 108, January, 1941, p. 48.

Corp., Highland Park, Mich. For mail: 1247 Alameda, Detroit, Mich.

SPEARS, J. T., Metallurgist, Sorel Steel Foundries, Box 644, Sorel, P. Q., Canada.

THOMASSET, P. A., Vice-President, Ansbacher-Siegle Corp., Rosebank, Staten Island, N. Y. For mail: 134 Campus Road, G.P.O., Staten Island, N. Y.

TULSA PUBLIC LIBRARY, TECHNICAL DEPT., E. D. Hart, Head, Technical Dept., Third and Cheyenne, Tulsa, Okla.

VIDAL, E. N., Engineer, U. S. Bureau of Reclamation, U. S. Custom House, Denver, Colo.

WALDRON, L. J., Metallurgist, National Bureau of Standards, Washington, D. C.

WAYNE UNIVERSITY LIBRARY, 4841 Cass Ave., Detroit, Mich.

WEST, L. P., President, West Bros. Brick Co., 719 Fifteenth St., N. W., Washington, D. C.

WEST VIRGINIA GEOLOGICAL AND ECONOMICAL SURVEY, P. H. Price, State Geologist, Box 879, Morgantown, W. Va.

WILLIAMSON, H. D. Instructor, Department of Mechanics, Materials Laboratory, Rensselaer Polytechnic Inst., Troy, N. Y.

WORTH, J. S., Assistant Metallurgical Engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.

Junior Members (7)

AGREN, D. E., Experimental Engineer, Industrial Wire Cloth Products Corp., Wayne, Mich. For mail: 4832 University Place, Detroit, Mich.

BEGG, L. C., Inspector, International Register Co., Chicago, Ill. For mail: 5610 S. Wells St., Chicago, Ill.

DUCHACEK, C. F., Junior Engineer, M. R. Scharff, Consulting Engineer, New York City. For mail: 41-11 Forty-eighth St., Sunnyside, Long Island, N. Y.

KELLY, J. B., Massachusetts Institute of Technology, Cambridge, Mass. For mail: 517 Beacon St., Boston, Mass.

REEDER, O. H., Chief Chemist, Baltimore Copper Paint Co., 501 Key Highway, Baltimore, Md.

RUDERMAN, IRVING, Chemical Engineer, Research and Development Dept., Panelyte Division, St. Regis Paper Co., Trenton N. J. For mail: 283 Spring St., Trenton, N. J.

SHINGLEDECKER, C. W., JR., Bethlehem Steel Co., Inc., Bethlehem, Pa. For mail: 648 Main St., Bethlehem, Pa.

PERSONALS

. . . News items concerning the activities of our members will be welcomed for inclusion in this column.

W. H. VAUGHAN, formerly Director of State Engineering Experiment Station, and Head of Ceramic Engineering Department, Georgia School of Technology, Atlanta, Ga., is now Chief, Regional Products Research Division, Commerce Department, Tennessee Valley Authority, Knoxville, Tenn.

G. A. HEFT, is now connected with Barnard, Godat & Heft, New Orleans, La. He was formerly Principal Designing Engineer, Union Station Project, New Orleans, La.

R. M. PALMER, President, Ferro-Nil Corp., New York City, has been awarded the "conspicuous alumni service" medal of Columbia University.

The following A.S.T.M. members have been selected by the nominating committee of the American Foundrymen's Association for nomination at the annual convention to be held in New York City the week of May 12 to 15: For directors to serve three years: L. N. SHANNON, Vice-President and Works Manager, Stockham Pipe Fittings Co., Birmingham, Ala.; R. J. ALLAN, Consulting Metallurgist, Worthington Pump and Machinery Corp., Harrison, N. J.

F. C. HOUGHTEN, Director of Research, American Society of Heating and Ventilating Engineers, Pittsburgh, Pa., was awarded an honorary degree of Doctor of Science by Olivet College, Olivet, Mich., at its annual Founders' Day convocation on February 24.

H. E. NEWCOMER, formerly Assistant Materials Engineer, is now Associate Materials Engineer, National Bureau of Standards, Washington, D. C.

W. T. BROWN is now connected with the Jones & Laughlin Steel Corp., Pittsburgh, Pa., as Research Engineer. He was formerly Research Engineer, Bethlehem Steel Co., Inc., Bethlehem, Pa.

A. R. DIMOCK, JR., is Assistant Engineer, Ford, Bacon & Davis, Consulting Engineers, New York City. He was Valuation Engineer, Ebasco Services, Inc., New York City.

C. A. HOGENTOGLER, JR., formerly Research Associate in Soil Mechanics, George Washington University, Washington, D. C., is now Lecturer on Soil Mechanics, University of Maryland; and Consultant on Soil Mechanics, Chevy Chase, Md.

C. A. ADAMS, Professor of Engineering, Emeritus, Harvard University, Cambridge, Mass., and Consulting Engineer, Edward G. Budd Manufacturing Co., Philadelphia, Pa., was awarded the 1940 Lamme Medal of the American Institute of Electrical Engineers, "for his contributions to the theory and design of alternating current machinery and his work in the field of electric welding." The medal and certificate will be presented to him at the annual convention of the Institute, which is to be held in Toronto, June 16–20, 1941.

JULIUS AVINS, formerly Chemical Engineer, Treadwell Construction Co., Midland, Pa., is now Chemical Engineer, Development Dept., The Solvay Process Co., Hopewell, Va.

J. W. KENNEDY, Engineer, Service Bureau, Huron Portland Cement Co., Detroit, Mich., has been elected a director of the American Concrete Institute.

F. J. CONVERSE, Assistant Professor of Civil Engineering, California Institute of Technology, Pasadena, Calif., with D. R. Warren, has formed the engineering partnership of Warren and Converse in Pasadena, Calif., for the purpose of making foundation investigations and supplying consulting foundation services.

H. AUSTILL, Chief Engineer, Gulf, Mobile & Ohio Railroad Co., Mobile, Ala., is now Chief Engineer, Terminal Railroad Association, St. Louis, Mo.

M. E. GILMORE is now Commissioner of Public Works, Washington, D. C. He was formerly State Engineer Inspector, Public Works Administration, New York City.

J. R. CARDWELL, who was Metallurgist, Walker Machine and Foundry Corp., Roanoke, Va., is now connected with the Maryland Sanitary Manufacturing Corp., Baltimore, Md.

C. E. BALES, Vice-President, The Ironton Fire Brick Co., was elected president of the Ohio Ceramic Industries Association at their annual meeting held in Columbus.

S. C. HOLLISTER, Dean, College of Engineering, Cornell University, Ithaca, N. Y., has been appointed regional adviser for the State of New York outside New York City on the national program for engineering defense training.

G. H. DENT, formerly Highway Engineer, Maryland State Roads Commission, Baltimore, Md., is now Airport Paving Engineer, Civil Aeronautics Administration, New York City.

ROBERT COWEN, who was connected with the Roxalin Flexible Lacquer Co., Inc., Elizabeth, N. J., as Vice-President and Plant Manager, is now with Jones-Dabney Co., Inc., New York City as Technical and Sales Representative.

F. G. ALLISON, recently District Concrete Engineer, Pennsylvania Turnpike Commission, Shippensburg, Pa., is now Airport Paving Engineer, Airport Section, Civil Aeronautics Administration, Atlanta, Ga.

C. B. KARLSON, is now President, Steel Products Sales Corp., New York City. He was Vice-President and Sales Manager, Seamless Steel Equipment Corp., New York City.

FOSTER D. SNELL, President, Foster D. Snell, Inc., Brooklyn, N. Y., has been proposed as councilor-at-large of the American Chemical Society for 1942.

W. F. ANGUS, formerly Vice-President, Canadian Car and Foundry Co., Montreal, P. Q., Canada, is now President, Dominion Bridge Co., Ltd., Montreal, P. Q., Canada.

E. M. GRIFFITH is now President, The Defiance Pressed Steel Co., Marion, Ohio. He was formerly Vice-President and General Manager, The Cuyahoga Steel and Wire Co., Cleveland, Ohio.

F. E. Amthor, President, Amthor Testing Instrument Co., Inc., has announced the purchase of a two-story factory building located at 45–53 Van Sinderen Ave., Brooklyn, N. Y. After some alterations the new building has been occupied and greatly increased facilities are available to handle the company's increasing activities.

R. F. Passano, who was Research Engineer, The American Rolling Mill Co., Middletown, Ohio, is now in the Research and Development Department, Bethlehem Steel Co., Inc., Bethlehem, Pa.

O. T. Barnett, formerly Metallurgist, Black, Sivalls & Bryson, Inc., Oklahoma City, Okla., is now Engineer of Tests, Metal and Thermit Corp., Jersey City, N. J.

F. H. Frankland is now Director of Engineering, American Institute of Steel Construction, New York City. He was formerly Chief Engineer of the Institute.

C. S. Sheldon, Engineer, Bridges and Structures, Pere Marquette Railway Co., after 47 years of railway service, has been retired, at his own request. Mr. Sheldon, who was the representative of the Pere Marquette Railway Co. in the Society for twelve years, is being succeeded both in his company and in the Society by O. E. Hager.

The Executive Committee of the American Welding Society has approved the appointment of a Section Advisory Committee to serve in the capacity of liaison officer between the National Board of Directors and the Sections, and the following A.S.T.M. members will serve on this committee: A. J. Moses, General Manager, Hedges-Walsh-Weidner Division, Combustion Engineering Co., Chattanooga, Tenn., and F. L. Plummer, Research Engineer, Hammond Iron Works, Warren, Pa.

F. K. Donaldson, General Superintendent, The Machined Steel Casting Co., Alliance, Ohio, was recently elected a member of the new board at a meeting of the board of directors of the Steel Founders' Society of America.

As a result of a national poll of the members of the American Chemical Society, officers have been elected for 1942, including the following A.S.T.M. members: Director: Robert E. Wilson, President, Pan-American Petroleum and Transport Co.; Councilor-at-large: G. E. F. Lundell, Chief, Chemistry Division, National Bureau of Standards.

Because of a change in position, the personal membership of H. Y. Bassett, who is now Superintendent of Tube Manufacture, Wolverine Tube Co., Detroit, Mich., has been transferred to J. S. Rodgers, who has been promoted to Head of the Technical Department, in charge of Laboratories and Mill Control. Mr. Bassett is a former subcommittee chairman, active in the work of Committee B-5.

The Rubicon Co., manufacturers of a wide range of instruments, announced as of February 1 the removal of its entire facilities to 3751 Ridge Ave., Philadelphia, from their down-town location. At the new location there has been possible a great expansion of its facilities.

Catalogs and Literature Received

American Instrument Co., 8010–8020 Georgia Ave., Silver Spring, Md. Bulletin 2089AU describing the Time Standard (Tuning Fork Controlled), a new precision laboratory oscillator, with many uses. This company also announces the publication of their new catalog of laboratory apparatus, (Catalog XA41) containing 184 pages, describing instruments and apparatus for chemical, biological, physical, clinical, pathological, research, engineering and materials testing laboratories.

Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa. Folder N-163(1), 4 pages, illustrated, describing new Daily-Tear-Off Device which makes Micromax strip-charts as easy to file as round charts. Records from all over the plant can be assembled every day for comparison and study of interrelated effects. Also, Catalog E-72, 20 pages, covering Photometers and Accessories. Included in this illustrated booklet are descriptions of the bar photometer, sphere photometers (both visual and photoelectric types) and the Macbeth illuminometer.

Taber Instrument Co., North Tonawanda, N. Y. Bulletin 4012, a 6-page folder, illustrated, describing the Taber Abraser (Research Model), a testing machine for evaluating resistance of surface finishes to rubbing abrasion, such as paints, lacquers, electroplated and plastic surfaces and textile fabrics ranging from sheer fabrics to upholstery.

Wilkens-Anderson Co., 111 N. Canal St., Chicago, Ill. Twenty-three page catalog, illustrated, entitled "Waco Catalyst," describing chemicals and laboratory supplies particularly applicable in the fields of chemistry and chemical engineering.

Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich. Leaflet No. 3500, covering the Specimen Briquetting Press, used to briquette powders, borings and milled chips of metals. Also, leaflet No. 3000, covering the Two-Minute Carbon Determinator, with varitemp furnace, purifying train and oxygen regulator, built for the accurate determination of carbon in ferrous and non-ferrous materials well within the two-minute limit, excluding the one weighing of the sample. Both leaflets illustrated.

The Refinery Supply Co., Tulsa, Okla., Catalog No. 26-A, a 100-page illustrated publication describing the range of laboratory apparatus and scientific instruments handled by this organization. Among the equipment described are a large number of instruments and apparatus required in connection with A.S.T.M. tests and specifications, particularly pertaining to the field of petroleum products and lubricants.

Schedule of Meetings

Date	Committee	Place
March 24, 25.	C-1 on Cement.....	Washington, D. C.
March 26.....	C-12 on Mortars for Unit Masonry....	Washington, D. C.
April 15.....	Executive Committee	Philadelphia, Pa.
April 18.....	Detroit District.....	Detroit, Mich.
June 23–27....	1941 Annual Meeting and Sixth Apparatus Exhibit..	Chicago, Ill.

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